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DICTIONARY OF EXPLOSIVES

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BY

MAJOR J. P. CUNDILL

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EDITOR'S PREFACE.

THE "Dictionary of Explosives" is based on a course of lectures delivered at the School of Military Engineering, by Major J. P. Cundill, R.A., one of H.M. Inspectors of Explosives.

This dictionary is published by the kind permission of Major Cundill, to whom our best thanks are due for the valuable work which he thus enables us to present to our subscribers; and, further, for his having offered to help us in keeping the work up to date.

It was originally intended to publish the "Dictionary of Explosives" as an Occasional Paper in the *R.E. Professional Papers*, but on further consideration it was seen that, to be of the greatest use, the Dictionary should take the form of an interleaved book, in which the description of new explosives, which are constantly being brought out, could be added.

Periodically the additions will be published as an extra Supplement to the *R.E. Journal*, and printed on one side of the paper only, for fixing on the blank pages. Spare copies of these additions will be kept, so that subscribers who require them, and who do not receive the *R.E. Journal*, will be able to obtain them.

The "Dictionary of Explosives" is presented to all subscribers to the R.E. Institute and *R.E. Professional Papers*.

FRANCIS J. DAY, *Major, R.E.,*
Secretary, R.E. Institute, and Editor,
R.E. Professional Papers.

Chatham, March, 1889.

AUTHOR'S PREFACE.

In the following pages I propose to set forth a "Dictionary of Explosives," which comprises all those which have, to my knowledge, been used or proposed to be used. The list includes a good many which are obviously unfit for practical purposes, and some which are merely curiosities in a chemical sense. All, however, are given without distinction.

Those which are, or have been, licensed for use in the United Kingdom will be specially noted as "authorised explosives," a term which signifies that they are, or have been, "authorised to be manufactured for general sale or imported for general sale," under the Explosives Act, 1875.

It may not be amiss to point out here that the authorization of an explosive in no way concerns its commercial or practical value. It simply means that a given explosive has, after due examination and testing, been found to be reasonably safe under ordinary conditions of transport, storage, and use.

I have divided the list into eight classes, as follows :—

I. Gunpowder, ordinarily so-called.
II. Nitrate mixtures other than gunpowder.
III. Chlorate mixtures.
IV. Nitro-compounds containing nitro-glycerine. This includes the great dynamite class.
V. Nitro-compounds not containing nitro-glycerine, *e.g.*, guncotton.
VI. Explosives in which picric acid or a picrate is a main constituent.*

---

* Picric acid is itself a nitro-compound, and explosives containing it or picrates would strictly fall into Class V., but for the sake of convenience I have placed them in a small separate class.

VII. Explosives of the Sprengel type, in which the principle is the admixture of an oxidising with a combustible agent (at the time of, or just before, being required for use), the constituents of the mixture being themselves non-explosive.

VIII. Miscellaneous explosives.

I do not pretend that in every case the limits of each class are very sharply and definitely defined. In many cases one class merges into another, but I have observed the foregoing classification as a whole, and been guided by the main distinctive features of the various explosives.

It will be apparent as the lists are gone through how often the same, or practically the same, idea has been patented and re-patented, and this is especially the case in the chlorate mixture class. Further, it will be seen in the dynamite class how many explosives, though passing under different names, are to all intents and purposes identical.

With Class I. (gunpowder), I have dealt very slightly indeed, for the literature on that head is very copious, and I have merely indicated a few propositions which have been made with respect to alterations from the ordinary methods of manufacture.

To each class I have prefixed a short introductory chapter dealing with the leading features of that class, and in the alphabetical lists I have given in almost every case the authority for the information concerning each individual explosive. The main authorities quoted are abbreviated as follows :—

The number and date of an English patent specification is given thus :—

Spec. No. 139, 18. 1. 62.

"D" refers to Desortiaux' translation (with additions) of the work of Drs. J. Upmann and E. von Meyer.*

"T" refers to Drinker's *Tunnelling.*†

"M" refers to *Notes on the Literature of Explosives*, by Professor C. E. Munroe, U.S.N.A., of the U.S. Naval Institute, Annopolis.

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* *Traité sur la poudre, les corps explosives, et la pyrotechnie.* Paris, 1878.

† *Tunnelling, Explosive Compounds, and Rock Drills*, by Henry S. Drinker. 2nd Edition. John Wiley & Sons, New York, 1882.

"Eissler" refers to *Modern High Explosives.*[*]

"B" refers to Berthelot. *Sur la force de matières explosives.* 3^{me} Edition. Ed. Gauthier-Villars. Paris.

I would call particular attention to the fact that I do not pretend to enumerate every form of matter possessed of explosive properties. Of these the quantity is innumerable, and the practical chemist is acquainted with scores of combinations which, under certain circumstances, are powerfully and dangerously explosive. To take the simplest instance, a mixture of oxygen and hydrogen in the proportions requisite to form water, is, weight for weight, one of the most powerful explosives known; while the very water created by the combination of these gases will, if closely confined and heated, give rise to explosion, as in the case of boiler accidents. Many other well-known gaseous mixtures, such as coal gas and air, are highly explosive, but such will not be mentioned here. Some of the more interesting chemical combinations are given in the miscellaneous class, but, as a rule, I have followed the definition given in the Explosives Act, 1875, Sec. 3, which states:—

"The term "explosive" in this Act,—

(1) "Means gunpowder, nitro-glycerine, dynamite, guncotton, blasting powders, fulminate of mercury and other metals, coloured fires and every other substance, whether similar to those above-mentioned or not, *used or manufactured with a view to produce a practical effect by explosion, or a pyrotechnic effect,*[†] and

(2) "Includes fog-signals, fireworks, fuzes, rockets, percussion caps, detonators, cartridges, ammunition of all descriptions, and every adaptation or preparation of an explosive as above defined."

NOTE.—This Dictionary originally appeared in the Proceedings of the Royal Artillery Institution. It is reprinted here with some alterations and additions.

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[*] *The Modern High Explosives*, by Manuel Eissler. John Wiley & Sons, New York, 1884.

[†] The point of the definition, in regard to substances not detailed by name, lies in the words which I have placed in italics.

By Sec. 104 of the Act, power is reserved to Her Majesty in Council to declare that any substance which appears to Her "to be specially dangerous to life or property, by reason either of its explosive properties, or of any process in the manufacture thereof being liable to explosion," may "be deemed to be an explosive within the meaning of this Act."

INTRODUCTORY.

High and Low Explosives.—Explosives are, in popular language, divided into "High" and "Low," and of these two classes dynamite and gunpowder may be taken as the respective types. No hard and fast line can be drawn between them, but, speaking generally, we may class as "high" explosives those which are habitually fired by detonation, and used for purposes where a destructive rather than a propelling effect is aimed at. The effect of an explosion in a confined space is two-fold. It produces *pressure*, tending to simple rending of the containing envelope; and, rupture being effected, *work* or projectile effects.

Pressure and Work.—The *pressure* developed depends on the volume and temperature of the resulting gases or vapours, the *work* upon the heat evolved by the chemical changes involved in the decomposition of the original substance. This heat, which is not to be confounded with the simple heat of combustion, can be approximately calculated by thermo-chemical methods and data.

Maximum Work or Potential.—The maximum work which can be effected by a given chemical decomposition, of which an explosion is a particular instance, is given by the formula $E = 425\,Q$, where E represents the maximum work or potential in kilogrammètres and Q the number of units of heat * evolved by that decomposition.

In practice only a fraction of this potential can be actually realised in the form of useful work, as a considerable amount is absorbed in heating the surrounding medium, in creating in it physical waves, and in various other ways. This fraction or modulus has been variously estimated in different cases at from 14 to 33 per cent. of the potential.

The formula given above shows that, *cæteris paribus*, the power of explosives may be compared by ascertaining the heat produced by their decomposition, provided that allowance be made for dissipation of energy due to comparative slowness of action.

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* A unit of heat is the amount of heat required to raise one gramme of water from 0° to 1° C. In some cases heat is absorbed in a chemical change, and, of course, then E would have a minus value, but for obvious reasons this does not take place in the case of explosions.

Theoretical Data.—In estimating theoretically the force of a given explosive we must know :—

(*a*). Its chemical constitution and the equation of its decomposition.

(*b*). The heat evolved in such decomposition.

(*c*). The nature and volume of the gases and vapours formed by the decomposition.

(*d*). The rapidity of the chemical reaction.

The chemical constitution, so far at least as regards the empirical formula, is a matter of simple analysis, and in cases where there is perfect combustion the nature of the resulting products may be predicted with considerable accuracy.

But when an explosive does not contain sufficient oxygen * to ensure perfect combustion the equation of decomposition is not as a rule so simple, and the products of decomposition will vary considerably with the method in which it is effected. Hence, instead of representing the result of the reaction by one equation, several simultaneous equations may be involved, or the results may be so complicated as to resist expression by equations at all. It is, therefore, necessary to find out what is the final result of the reaction or series of reactions involved when a given explosive is fired in the way, and under the circumstances equivalent to the use to which it is desired to put it in practice. When we have obtained the equation or net result as above, the amount of heat evolved can be estimated from the data furnished by thermo-chemistry. The volume and consequent pressure of the gases and vapours can be calculated by well known laws, assuming that such laws, known to hold good for ordinary temperatures, hold good also at the elevated temperatures obtained at the moment of explosion. In the present state of knowledge we are not able to say whether this is the case or not, but it is probably true for the so-called permanent gases.

Thermal Values.— In estimating the thermal value of any chemical reaction it is only necessary to know the initial and final changes of the changing system. It is, indeed, a simple case illustrating the principal of conservation of energy.

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* It has been somewhat loosely said that the power of an explosive may be gauged by the amount of available oxygen it contains up to that amount necessary to give complete combustion. Practically this is not correct ; moreover many highly explosive substances contain no oxygen at all, such as chloride of nitrogen. The mistake arises from confusing the heat of combustion with the heat evolved.

For instance, the heat formation of a molecule of formic acid (CH_2O_2) is 99,420 units. The same amounts of carbon and hydrogen that are contained in that molecule when burnt in oxygen to form respectively carbonic anhydride and water give a total of about 165,320 units. Hence the heat evolved by burning the molecule in oxygen is 165,320 – 99,420 = 65,900 units. *

Dissociation.—From what has been said, it is apparent that if, as must often be the case, dissociation of the ultimate products of explosion takes place at the very high temperatures concerned, the total amount of heat evolved, or of potential, is not thereby effected. The tendency of dissociation is to diminish the initial pressure as less heat is evolved, but as temperature falls, this missing heat is reproduced in the union of the dissociated elements.

In short, if a given area represent the potential it is not altered by dissociation, but the configuration of its bounding line is altered much in the same way as the curve of pressure given by a slow gunpowder differs from that given by a quick one, though the total work may be the same.

Rapidity of Chemical Action.—The rapidity of chemical reaction is a very important factor. A piece of wood may slowly decay, and in the process evolve much the same ultimate products and amount of heat as when burnt in a furnace, but a boiler is not readily heated by letting wood slowly decay underneath it. The process is so slow that the heat or energy is dissipated as fast as it is evolved. Hence it is essential that the chemical changes involved in the decomposition of an explosive when practically applied should be extremely rapid.

To test the conclusions theoretically arrived at as to the power of an explosive, several methods have been suggested and tried. One very good practical test is due to Sir F. Abel. It is to bore vertical holes in cylindrical lead blocks, the latter being of as uniform material as possible, and of such dimensions as not to be disrupted by an explosion of a substance contained in the holes. Equal weights of different explosives are taken, placed in the bore-holes, tamped with water or fine sand, and fired electrically or otherwise.

The relative effect of the different explosives is shown by the increased cavities in the blocks after firing. The cylindrical hole usually becomes a pyriform chamber, whose capacity is readily measured by determining the volume of water which it will contain and comparing this with its previously known capacity.

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* *Manual of Chemistry.* Duprè and Hake. Vol. I., p. 72.

This method is not, however, readily applicable to slow explosives, as the tamping is blown away before the chamber is fully formed. Even in the case of high explosives variations are found depending on the physical condition of the explosive. For instance, rigidly frozen blasting gelatine gave considerably more effect than the same substance unfrozen. In the case of the latter, the bell-mouthed form of the upper portion of the cylindrical hole showed that portions had exploded while actually passing out of the top of the hole.

Various modifications of crusher gauges have also been tried, notably the dynamometrical ring used by General Abbot, U.S.A., for ascertaining the relative effect in horizontal and other planes of various explosives immersed under varying depths of water. The results of his experiments are very striking, and forcibly point out the fact that the surrounding medium plays a very important part in the behaviour of explosives.

Indeed, speaking generally, it may be urged with much force that though theory may give very good guidance as to what may be expected of an explosive, and may satisfactorily explain apparent anomalies and eccentricities in its behavour, yet nothing short of actual trial of that explosive under the circumstances and conditions under which it is proposed to use it, will give thoroughly dependable results as to its value.

To ask in a general way what is the best explosive for blasting is much the same as to ask what is the most useful tool in a carpenter's chest.

For instance, if in driving a tunnel heading it is found that with a given expenditure of time and money an explosive A gives a more rapid rate of progress than an explosive B, then clearly for that particular work A *cæteris paribus* is preferable. But it by no means follows that when the heading has got into another kind of rock A will maintain its superiority. When the object is simply to shatter the rock a quick and powerful explosive should be used; when, on the contrary, it is desired to obtain the rock in large blocks or masses, as in the case of slate or granite, then a slow explosive producing a rending, rather than a locally shattering effect, is preferable. Dynamite, for instance, is often extremely useful in sinking a shaft for coal, but when the coal itself is to be won, gunpowder, or, at all events, a slower explosive than dynamite, is commonly employed.

Practical considerations applying to explosives in general.—There are certain practical considerations which govern the choice and use of explosives in general, apart from any particular application of them.

The explosive should not be too bulky, for the less its density the greater will be the labour involved in boring holes to receive it. Moreover, a dense explosive will, other things being equal, evolve relatively more volumes of gas than a light and bulky one.

It should be reasonably safe to handle, transport, and store under ordinary conditions and when subjected to ordinary precautions, allowing for such amount of rough usage as it may fairly be expected to meet with. For instance, several explosives, powerful in their nature, and chemically stable, have been proposed for general use, which could be readily exploded by a wooden mallet or broomstick on a wooden floor. This was especially the case when the blow was of a glancing character, thereby combining friction and percussion. Such a blow is precisely what might be expected when charging a bore-hole, and for this reason such explosives have been considered too sensitive for general use. As will be noted in the introduction to the chlorate mixture section, many explosives containing chlorates became considerably more sensitive when left for a few months, especially if alternately exposed to moist and dry air.

Chemical stability, under lapse of time, and at varying natural temperatures, is essential, more particularly for service explosives, which may be expected to be stored for a considerable length of time, and to be subjected to extreme atmospheric temperatures. The explosions of the blasting gelatine magazines at Aden in May and June, 1888, furnish a very practical commentary on the importance of this point.

It is to be noted that a very small portion of impure or unstable material may, by its decomposition, ignite and finally explode large amounts of contiguous explosive, though this may be perfectly pure and stable in itself. The impure portion acts as a primer to the rest.

An explosive intended for use in mine galleries or other confined spaces should not give off actively poisonous gases or vapours, nor, so far as can be avoided, deleterious, either before or after explosion.

Practically, the explosion fumes of any explosive are more or less injurious in confined spaces, but some much less so than others.

Liquid explosives, or those which exude explosive liquids, are dangerous to convey or store owing to the risk of leakage, and are unfit for use in seamy ground, as some liquid may flow into a distant crevice unnoticed until itself accidentally struck by a boring tool, or otherwise exploded. Accidents are on record due to this cause in which the liquid had remained *perdu* for years.

In connection with this point it may not be superfluous to add that all holes which have not "carried their burden" should be most carefully searched before again boring into or very near them.

An explosive which gives off acid or other corrosive fumes under ordinary conditions of storage is highly dangerous, as it may very possibly induce the spontaneous ignition of other explosives stored with it.

Distinction between military and civil explosives.—At the same time a broad distinction is to be drawn between explosives used for emergent military purposes by experts, and those which are safe to trust in the hands of the ordinary miner. Occasions may well arise when an Engineer Officer would gladly avail himself of a powerful explosive which would be most objectionable for ordinary industrial purposes. Many such explosives could be readily manufactured in a very brief time from materials present in nearly every town as articles of commerce. In any calico printing establishment, for instance, a perfect mine of material for rough and ready, but powerful, explosives exists.

Effect of mixtures of inert substances with explosives.—The effect of the admixture of an inert substance with an explosive varies considerably with their respective natures.

If the inert substance be of such a nature and be present in such quantity as to interpose between and insulate from each other the physical particles of the explosive, then the mixture will become much slower and less sensitive, or cease altogether to be explosible. As an instance of this may be cited the proposal of Mr. Gale to render gunpowder safe by mixing it with ground glass, which latter was to be sifted out when the powder was required for use.

Suppose a piece of honeycomb to represent a mixture of an explosive with inert matter. If the honey in the cells represents the explosive and the waxen walls the inert substance, then the mixture will be difficult to explode, at least by ordinary means. Such a state of things occurs when an inert liquid or melted solid is introduced into guncotton.

If, however, the circumstance be reversed, and the honey represents the inert matter and the wax the explosive, then we have a state of things like ordinary dynamite, in which each particle of kieselguhr absorbs, and is more or less surrounded by a continuous film of nitro-glycerine. As the continuity of the film is diminished, so the explosibility is lessened. Hence a mixture of kieselguhr with a very low proportion of nitro-glycerine is hardly an explosive; all the liquid is absorbed in the porous particles of the kieselguhr, and there is no connecting film. If, however, we substitute some non-porous substance, such as flakes of glass, or mica, for the absorbent, then each of the flakes will carry a surrounding film, and with a low proportion of nitro-glycerine we still have a powerful explosive.

The addition of a small percentage of camphor or certain hydrocarbons to blasting gelatine or compressed gun-cotton considerably diminishes their sensibility, but the same addition to a dis-continuous powder is said not to produce the same effect.

Sensibility of explosives.—The sensibility of explosives to ignition or friction varies very considerably, and a low igniting point does not necessarily carry with it increased susceptibility to shock. For instance, fulminate of mercury fires at 190° C, oxalate of silver at 130° C, but the former is very much more easily exploded by friction than the latter.

The sensibility of a given explosive is considerably affected by its state of physical aggregation, as in the cases of compressed gunpowder and guncotton.

Temperature also plays an important part, for a very slight shock will induce the explosion of heated dynamite or guncotton, and even celluloid,* now much used for ornamental articles, will explode under a hammer when warmed to its softening point. Again, frozen dynamite or nitro-glycerine is comparatively insensible to a blow, while the reverse holds good with frozen blasting gelatine.

As a rule the sensibility of any chemical substance may be broadly stated to vary inversely with the temperature required to start decomposition, and with the specific heat, and directly as the heat evolved by the decomposition.

The special properties of any particular explosive, where such appear to require particular mention, will be found in the following sections, and more especially in the introduction to each section.

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* Essentially a mixture of nitro-cotton and camphor.

A DICTIONARY OF EXPLOSIVES,

BY MAJOR J. P. CUNDILL, R.A., H.M.'S INSPECTOR OF EXPLOSIVES.

CLASS I.—(GUNPOWDER).

I DO not propose to dwell at length on this class, for the reason stated in the Preface. While during the past few years the manufacture and treatment of gunpowder for artillery purposes has received the closest attention, resulting in the production of powders differing most widely in physical characteristics from each other, and from the sweet simplicity which characterized the old powders in use some quarter of a century ago, the actual proportion of ingredients for black gunpowder has varied but little, if at all, and now, as then, the composition of nearly all descriptions of service gunpowder consists of the time-honoured 75 parts of saltpetre, 15 of charcoal, and 10 of sulphur.

While some Continental countries follow this formula, others somewhat vary the proportions. For instance, the ordinary French service gunpowder consists of the ingredients in the proportion of "*six, as, as*," or saltpetre 75, charcoal 12·5, and sulphur 12·5.

Ordinary blasting powder* differs, broadly speaking, from the classes of powder in containing less saltpetre, and in being milled a shorter time, as a rule; also, less attention is paid to the charcoal used.

Briefly, the manufacture of gunpowder may be summarized as consisting of the following operations:—

1. Mixing the previously purified and sifted ingredients to form a "green," or "unworked" charge.
2. Milling (incorporating) the mixture to form mill-cake ("ripe," or "worked" charge).

---

* Blasting powder and gunpowder are sometimes spoken of by retail dealers as if quite different substances. They are, of course, identical, or, rather, blasting powder is simply a cheaper and inferior class of gunpowder. At the same time Desortiaux (p. 600), points out that not only is a powder rich in charcoal cheaper than ordinary powder, but that it may be expected to furnish a larger volume of gas when exploded, and he quotes Piobert in support of this theory. Hence, for blasting purposes, it is quite possible that a cheap powder, poor, comparatively speaking, in saltpetre, may be equal, or superior, to one of the ordinary composition.

3. Breaking down mill-cake. (This is omitted in many factories).
4. Pressing.
5. Granulating, or "corning."
6. Dusting.
7. Glazing.
8. Drying in a stove.
9. Finishing, or final dusting.

In different factories the system employed in each of the above operations may differ in some degree, and in one or two cases the order of one or two processes may be changed, but the above is a sufficiently accurate general description.*

Of the ingredients mentioned, the charcoal is by far the most important, in one sense, for on its treatment depends much of the character of the gunpowder of which it forms a part. The material from which the charcoal is prepared, and the methods of carbonising this material, require most anxious attention, and the popular saying that "gunpowder all depends on the charcoal," is not far wrong.†

The properties of a given powder manufactured from given ingredients in given proportions depend on the physical characteristics of the finished powder, *e.g.*, length of milling, pressure given, amount of glazing, moisture, size and shape of grains or blocks, and their gravimetric density. These and other points go to make the art of making a really high-class powder suitable for a given task a matter of no small difficulty, as is shown by the care now found requisite in the manufacture, as compared with the somewhat haphazard methods employed some years ago.

It would be impossible, and, indeed, out of place here, to give at any length the history and manufacture of gunpowder, embracing the now numerous varieties of that explosive, and I will, therefore, merely indicate a few variations from the ordinary methods of manufacture :—

BOWEN proposed to make gunpowder from a mixture of 18 to 21 parts of carbonised and ground lignite, 4 parts of sulphur, and 74 to 77 parts of saltpetre. (Spec. No. 3,876, 9. 8. 83.)

He also used charcoal made by carbonising maize and other cereals. (Spec. No. 3,953, 13. 3. 86.)

BROWN POWDER is a special variety of gunpowder now largely used with heavy ordnance. Its manufacture originated in Germany, but is now carried on in this country. It differs from ordinary gunpowder in the proportions of its ingredients, which

---

* Of course, special varieties of powder, *e.g.*, prism powders, require exceptional details of treatment, *e.g.*, no glazing is required, as the prisms are pressed from grain powder.

† Pure saltpetre and pure sulphur obviously admit of no alteration by treatment consistent with retaining their purity, but charcoal may be made of innumerable varieties.

79
3
18
100

7.9
.3
1.8

are, for the description used in this country for military purposes :—

Saltpetre ...	... 79	parts.
Sulphur ...	... 3	,,
Charcoal ...	... 18	,,

The charcoal used is usually made from straw, carbonized in a special manner, the details of which are kept secret. There are also some other peculiarities in the method of manufacture of this powder which cannot be given here. The finished powder is in the form of hexagonal prisms, compressed from grain powder, and having an axial perforation.

This powder gives very high velocities combined with moderate pressures on the gun. It is much less readily ignited than the ordinary powder, and burns without explosion (so far as is yet ascertained) in the open. Cartridges made up with it require a small primer of black powder to start the action.

The following comparison, made by Noble and Abel, is quoted in the *Journal of Society of Arts*, 14. 12. 88 :—

	Cocoa Prism.	Black Pebble.
Units of heat evolved per gramme ...	837	721
Volume of permanent gases in C. C. ...	198	278

Other forms of brown powder have been recently introduced for sporting purposes.

Cocoa Powder, *see* Brown Powder.

Davey and Watson proposed to impregnate gunpowder with liquid or gaseous hydrocarbons or melted solid hydrocarbons. (Spec. No. 2,641, 29. 7. 74).

Drayson proposed to dissolve saltpetre in half its weight of warm water, and to mix the solution with the requisite proportions of sulphur and charcoal in the mill. The ingredients thus mixed were to be ground, dried, and finished in the usual manner. (Spec. No. 2,427, 31. 10. 55).

In a subsequent specification, he proposed to inject steam into a mixture of the usual ingredients enclosed in a vessel, and in quantities sufficient to give adhesiveness to the composition. He proposed further to grain the powder direct from mill-cake, instead of first pressing it in the usual way. (Spec. No. 292, 4. 2. 64).

Drayson's process was tried at the Dartmoor Gunpowder Mills, but abandoned, chiefly in consequence of a serious explosion.

Durnford uses light inflammable charcoal made from cork in the proportion of 20 parts charcoal to 80 parts of saltpetre, with or without the addition of 1 to 10 per cent. of sulphur. He claims this as "smokeless" and non-hygroscopic powder. (Spec. No. 3,578, 13. 3. 86).

Goodyear proposed to employ indiarubber or guttapercha (apparently in lieu of charcoal) in the manufacture of gunpowder. (Spec. No. 1,703, 26. 7. 55).

Greene reproduced Drayson's process, with the addition of mixing the ingredients in a vacuum or partial vacuum (T., p. 103).

Güttler proposed to make cartridges of compressed blasting powder by cementing the grains together with dextrine. He used a brown-red charcoal made from wood free from resin, at a temperature of about 290° C. This charcoal was said to have the formula $C_8H_4O_2$. (M., No. V., p. 749).

Hodge injected steam into the mixed ingredients of gunpowder with a view of dissolving the saltpetre, and thoroughly combining the ingredients. (Spec. No. 2,227, 22. 8. 57).

Hope substitutes for the whole or a portion of the charcoal: starch, flour, sugar, or other like organic material containing carbon, oxygen, and hydrogen. Also bitumen or other solid hydrocarbon to ensure more perfect combustion. (Spec. No. 14,914, 12. 11. 84).

Hunt proposed to mix the ingredients with sufficient water to make a very thin paste, and to combine them in this condition in a revolving drum suitably fitted. (Spec. No. 3,775, 12. 12. 72).

Maxwell simply diminished the amount of saltpetre "4 per cent., more or less," and used spirit, or spirit and water, instead of water alone in liquoring. (Spec. No. 1,066, 27. 4. 60).

Meurling, *see* Nordenfelt.

Neumeyer proposed gunpowder consisting of—

Saltpetre	75·00	parts.
Charcoal	18·75	,,
Flower of sulphur	6·25	,,

He preferred charcoal made from birchwood, and soaked the charcoal in soda-lye. He claimed that gunpowder thus made burnt quietly and slowly when unconfined, but had equal force to ordinary powder when confined. (Spec. No. 1,636, 17. 6. 65).

He afterwards proposed a mixture of—

Saltpetre	72	parts.
Charcoal	18	,,
Flower of sulphur	10	,,

abandoned the use of soda-lye, and mixed his ingredients

with 40 per cent. of water in a drum, fitted with revolving arms, for 15 minutes. The resulting compound was simply dried, and stated to be then fit for use. (Spec. No. 1,408, 13. 5. 67, and D. p. 601).

NORDENFELT, in conjunction with MEURLING, proposed to manufacture gunpowder, in which he employed a brittle substance, prepared from cotton or other woody fibre, by treating it with hydrochloric acid gas. This substance is thoroughly mixed with the proper amount of a saturated solution of sulphur in carbon bisulphide, in a closed vessel provided with a mechanical agitator. The dried mixture of carbon and sulphur is saturated with an aqueous solution of saltpetre, and the compound dried and finished as usual.

The brittle substance mentioned above would appear to be hydrocellulose, as described by Girard, or fulminose, as described by Blondeau. It is an isomeric modification of cellulose, and is produced by the action of acids, or heat, on that substance. It is extremely brittle. (M., No. I., p. 311. No. X., p. 195). (Spec. Nos. 6,514-15, 18. 4. 84, and Watts' Dic. of Chem.).

OLIVER substituted peat for charcoal, and, in cases where an extra strong powder was required, substituted chlorate of potash mixed with a small amount of beeswax, tallow, or resin, for the sulphur. (Spec. No. 1,800, 10. 6. 69).

STONES, like Oliver, whom he considerably preceded, also proposed to use charred peat in the manufacture of gunpowder. (Spec. No. 12,990, 7. 3. 50).

WATSON, *see* DAVEY.

WIENER proposed to mix the ingredients of gunpowder in a dry state, and subject them to action of a steam-heated press at a temperature of about 250° F. The sulphur melted at this temperature, and became thoroughly distributed throughout the mixture, converting the whole into a compact homogenous black cake. (Spec. No. 3,731, 17. 11. 73).

Experiments were tried with this method of manufacture at Woolwich in 1878. The prospective advantages claimed were—

1. Decrease of the power of absorbing moisture.
2. Economy of manufacture, by doing away with stoves and mills.
3. Diminution of the danger of manufacture due to the presence of small quantities of gunpowder in any one working building.

The English experiments failed, however, to produce a satisfactory powder, and it was ascertained that in the manipulation by Wiener (Colonel Viner) the mixture had been raised to the fuzing point of saltpetre, which approximates to the firing point of gunpowder, and that several explosions had occurred. Consequently the matter was dropped, but a few experiments were tried with ordinary powder heated to the melting point of sulphur, the idea being to coat each grain with a film of sulphur, or allow the latter to penetrate the charcoal. The trials were fairly successful, but not to such an extent as to warrant further experiments on a large scale. Gunpowder treated in this way was called "Baked Powder." (Reports of Com. on Explos. Sub., 1880-1).

CLASS II.—(NITRATE MIXTURES OTHER THAN GUNPOWDER).

Of the explosives detailed in this class, a very large number are simply modifications of ordinary gunpowder, and differ from the latter only in the proportion of the ingredients, or by the addition of some other ingredients.

In many cases the main point is the substitution of other nitrates for the whole, or for a portion, of the nitrate of potash in ordinary gunpowder. Such nitrates are those of sodium, barium, and ammonium.

Sodium nitrate (Chili saltpetre) contains 56·47 p.c. of oxygen; ammonium nitrate contains 60 p.c.[*]; potassium nitrate, 47·48 p.c.; and barium nitrate, 36·78 p.c.

It would, therefore, at first sight, appear to be highly advantageous to substitute one of the two first-named for saltpetre in gunpowder. Unfortunately, however, both of them are extremely hygroscopic, especially the ammonium nitrate, and consequently gunpowder made with them would, under ordinary conditions, soon become useless from damp absorbed from the atmosphere. In a hot dry climate, nitrate of soda powders, especially if made only a short time before being required for use, would doubtless be valuable[†] and be cheaper than gunpowder, and such powders were used to a considerable extent in the construction of the Suez Canal. Absolutely pure nitrate of soda is stated not to be unduly deliquescent, but the material as found in commerce contains other salts which are supposed to induce this property, and are difficult to remove by any reasonably economical process. The salt, however, is indirectly largely and increasingly used in the manufacture of gunpowder, for

---

[*] But only one-third of this, viz., 20 per cent., is available as free oxygen, the remainder being required to form water, thus: $NH_4NO_2 = N_2 + 2H_2O + O$.

[†] It is stated on the authority of Berthelot that powder made with nitrate of soda is about one-third stronger than when made with saltpetre. (D. p. 605).

by the simple process of boiling it with chloride of potassium,* it is converted into nitrate of potash, which is retained in the hot solution, while chloride of sodium is deposited. The principle of the process is the general rule that if two salts are dissolved together, which can form by exchange of their metals a salt less soluble in the liquid, that salt will be deposited. Thus :—

$$Na\,.\,NO_3 + KCl = KNO_3 + Na\,Cl.$$

The only apparent object of the use of nitrate of baryta is to produce a slow-burning powder, an end now generally attained by varying the physical characteristics of ordinary powder, notably as regards the size and shape of the grains.

AIX-LA-CHAPELLE POWDER is so-called from the place where it was tried. It consists simply of nitrate of soda and coal dust. (D. p. 609).

AMIDE POWDER consists of charcoal, saltpetre or its equivalent, and an ammonium salt in such proportions that on ignition a volatile and explosive amide compound is formed.

The proportions given are :—

Saltpetre	101	parts.
Nitrate of ammonia	80	,,
Charcoal	40	,,

or in the form of a chemical equation :—

$$KNO_3 + H_4N\ (NO_3) + 3\ \ C = KH_2N + H_2O + CO + 2(CNO_2).$$

Some samples, however, contain the ingredients in different proportions to those given above.

The potassamide (KH_2N) is stated to be volatile and explosive at high temperatures, and to increase the useful effect of the powder. It is also claimed that very little, if any, residue is left, that no gases injurious to the gun are produced, and that there is much less smoke than with ordinary gunpowder. (Spec. No. 14,412, 24. 11. 85).

BENNETT'S POWDER consists of the ordinary ingredients of gunpowder, to which a proportion of slaked lime, gypsum, or good cement is added. The mixture is made into a hard paste, which is subsequently granulated.

The proportions given are :—

Saltpetre	65	parts.
Sulphur	10	,,
Charcoal	18	,,
Lime	7	,,

(D., p. 600. Spec. No. 3,206, 21. 12. 61).

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* Chiefly obtained from carnallite (KCl, Mg, Cl_2 $6H_20$), a mineral found in great quantity at Stassfurth in Saxony, lying over beds of rock salt. It resembles the latter in appearance, and contains 16 to 18 p.c. of potassium chloride. It is very deliquescent.

Bleckmann's Powder (also called **Haloxyline**) consists of sawdust freed from resinous matter, or other powdered cellulose substances, saltpetre, and charcoal, with the occasional addition of ferrocyanide (yellow prussiate) of potash, when a quick explosion is required.

The proportions are :—

Sawdust	9	parts.
Charcoal	3 to 5	,,
Saltpetre	45	,,

The substances are mixed, moistened with one pint of water to about 112lbs. of the mixture, crushed and ground in a mill, made into cake, and treated like ordinary gunpowder. (Spec. No. 1,341, 10. 5. 66).

Bolton's Powder consists of :—

	Parts.		Parts.
Carbonate of copper ...	8	Nitrate of soda	350
Graphite...	10	Soda ash	20
Prepared quicklime ...	14	Ferrocyanide of potassium	300
,, alum	50	Charcoal	30
,, sugar	350	Carbonate of potash ...	450

The carbonate of copper, lime, nitrate of soda, soda-ash, and carbonate of potash are mixed with one half of the graphite and charcoal to form one mixture, the remainder of the ingredients with the remainder of the graphite and charcoal to form another mixture. Each of these is stated to be inexplosive and harmless. When required for use the two mixtures are to be combined. (Spec. No. 342, 31. 1. 68).

Bradbury, *see* **Harrison**.

Buckley, *see* **Harrison**.

Budenberg, *see* **Schäffer**.

Cahuc, *see* **Safety Blasting Powder**.

Carbo-azotine, *see* **Safety Blasting Powder**.

Courteille's Powder (also called **Triumph Safety Powder**) consists of the following ingredients :—

Nitrate of soda or potash ...	60 to 75 parts.
Sulphur	10 ,, 12 ,,
Charcoal	7 ,, 10 ,,
Peat and hard coal	9 ,, 12 ,,
'Combined metallic sulphates'	2 ,, 4 ,,
Oleaginous matter, animal or vegetable (or tar), refined or crude...	1 ,, 3 ,,

The mixture is saturated with steam, and then heated by superheated steam till nearly dry, the temperature being gradually reduced from 250° F. to 150° F. The powder is then dried on hot plates. The advantages claimed are slow combustion, due to the use of peat, charcoal, and hard coal, also freedom from explosion in the open, or by friction or percussion. An essential principle claimed is that a comparatively large volume of the ingredients of gunpowder being mixed with a small volume of the other ingredients will, under proper conditions, when exploded in a close chamber or under pressure, form nitro-glycerine (!), or an equivalent thereof, and thereby constitute a powerful explosive This claim appears to be founded on highly doubtful grounds, if indeed on any. (Spec. No. 3,217, 14. 9. 75, and T., p. 103).

CRAIG proposed to use nitrates of lime and magnesia in conjunction with nitrate of soda, and to coat each grain of powder with a film of collodion. (D., p. 605).

DALE, *see* ROBERTS.

DAVEY'S POWDER. In this powder, flour, bran, starch, or other glutinous or starchy matter, is employed to replace a portion of the charcoal ordinarily contained in gunpowder. Nitrate of soda may also be substituted for saltpetre, provided that waterproof envelopes are provided for the powder. The object of the invention is to reduce the amount of smoke produced on firing.

The proportions given are :—

	Parts.			Parts.
Saltpetre	64	or	Nitrate of soda ...	63
Sulphur	16		Sulphur	15
Charcoal	12			
Flour, bran, or starch	8			

(Spec. No. 2,478, 5. 11. 58).

DE MERCADER, *see* DE TERRÉ.

DE TERRÉ'S POWDERS consist of sawdust or similar carbonaceous substance, saltpetre, nitrate of soda, coal dust, lignite dust. He recommends the following proportions :—

For blasting in marble, granite, or other hardstone.	Parts.	For blasting in limestone, chalk, coal, or other soft stone.	Parts.
Sawdust	12·5	Sawdust	11
Saltpetre	67·5	Saltpetre	51·5
Sulphur	20·0	Nitrate of soda ...	16
		Coal or lignite dust	1·5
		Sulphur	20

(Spec. No. 2,715, 13. 10. 71).

DE TRET'S POWDER, known also as PYRONOME, consists of :—

Nitrate of soda	52·5 parts.
Spent tan	27·5 ,,
Sulphur...	20·0 ,,

The ingredients are boiled together and dried. It is a slow-burning powder of no great strength. (Spec. No. 1,226, 17. 5. 59).

DIECKERHOFF'S POWDER (*see* also HERAKLIN) consists of gunpowder mixed with not more than 15 per cent. of precipitated alkaline picrate or picrates, the object being to increase the explosive power of gunpowder without increasing its liability to accident or ignition. It is claimed also that a mixture of nitrate with sulphur and picrate in the above general proportions, without charcoal, is practically equivalent to the above, as experience has shown that charcoal is not essential to the compound. (T. p. 106).

DIORREXIN, an Austrian explosive, consisting of :—

	A	B
Nitrates of potash and soda	75	60
Sulphur	12	12
Sawdust	13	10
Charcoal...	—	7
Picric acid	—	1·5
Moisture...	—	7·5

(*Mining Journal*, 18. 6. 87).

EATON'S POWDER, a coarse-grained, slow-burning powder, containing nitrate of soda. It has been tried in firearms mixed with quicker powder, the object being to obtain a sort of progressive powder. (D. p. 607).

ESPIR'S POWDER was licensed for manufacture in this country at a factory near Plymouth, but the manufacture has been abandoned, and the amount hitherto consumed has not reached any great proportions. The license defines it as a mechanical mixture of nitrate of soda, sulphur, and sawdust. The specification gives the following composition :—

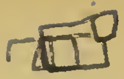
Nitrate of soda	60 parts.
Sulphur	14 ,,
Sawdust...	26 ,,

It was made in a wet state, one pint of boiling water being used to dissolve two pints of nitrate of soda. The solution was poured on to, and well mixed with, the other two ingredients, and the whole dried and sifted. Close confinement is necessary to develope the explosive forces of this powder, it being stated to be quite non-explosive in the open air. It is stated to improve by age. (Spec. No. 291, 26. 1. 75).

ESSELENS, *see* WYNANTS.

FEHLEISEN, *see* BLECKMANN.

FORTIS EXPLOSIVE, *see* GLYCERO-NITRE.



Me!
ME!

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FREIBERG POWDER consists of :—

Nitrate of soda	61·66 parts.
Sulphur	17·25 ,,
Charcoal	17·35 ,,

(D. p. 609).

GACON'S POWDER consists of 69 parts of potassium, or sodium nitrate, and 19 parts sulphur. The ashes of dead leaves are added, and finally a solution of tannin in water. It is said to require a temperature of 900° F. to ignite it, and to be absolutely insensible to percussion. (Spec. No. 5,735, 13. 12. 83.

GALLAHER'S POWDER consists of :—

Nitrate of soda, or ,, potash	70 to 80	parts.
Sulphur	6 to 12	,,
Sulphate of iron ...	1 to 3	,,
Charcoal	8 to 16	,,
Sulphate of copper ...	0·5 to 1	,,
Ground bark	8 to 14	,,

It is claimed to be safer than ordinary blasting powder, and not to be liable to ignition by friction or percussion. (T. p. 106).

GEMPERLÉ mixes saltpetre with ground bran, ground charcoal, sulphur, and a small amount of sulphate of magnesia. The mixing is done with the wet ingredients. (Spec. No. 2,407, 22. 5. 82).

GLYCERO-NITRE, proposed by Heusschen, consists of :—

	1	2	3	4	5	6	7	8	9
Nitrate of Potash	65·01	66·02	67·03	68·04	69·05	70·06	72·08	74·10	93·19
Sulphur	12·00	12·00	12·00	12·00	12·00	12·00	12·00	12·00	12 00
Lampblack ..	3·00	3·00	3·00	3·00	3·00	3·00	3·00	3·00	3·00
Tan BARK. ..	20·00	20·00	20·00	20·00	20·00	20·00	20·00	20·00	25·00
Sulphate of Iron	1·39	2·78	4·17	5·56	6·95	8·34	11·12	13·90	27·80
Glycerine	0·92	0·92	0·92	0·92	0·92	0 92	0·92	0·92	1·84
	102·32	104·72	107·12	109·52	111·92	114·32	119·12	123·92	162·83

The first five materials are powdered, wetted, and evaporated nearly to dryness. It is then completely dried, cooled, and the glycerine added to it. It is a black powder. It is claimed that various forms of nitro-glycerine are produced in the act of explosion in a blast-hole. (Spec. No. 1024, 8. 1. 84). The mixture, and the advantages claimed, are much the same as in the case of *Courteille's Powder*, *q.v.*

This explosive has been submitted for authorisation in this country under the name of "Fortis" and it has been intimated that, subject to certain conditions, licenses will be granted for it.

FORTIS NO. 2 consists of the same materials as Fortis or glycero-nitre, with the addition of sulphuric acid and naphthalene. The process of manufacture is such that no free acid is left in the finished product, nor is liable to be subsequently generated therein.

GRENADINE, *see* GACON.

HALOXYLINE, *see* BLECKMANN.

HARRISON'S POWDER consists of :—

Saccharum (saccharine matter) ...	50 parts.
Saltpetre	48 ,,
Club moss (lycopodium clavatum)...	2 ,,

(Spec. No. 1,786, 24. 7. 60).

For other powders proposed by Harrison, *see* Chlorate mixtures.

HERAKLIN consists of picric acid, nitrates of potash and soda, sulphur, and sawdust (of oak or other hard wood). It is manufactured as follows :—In 36 parts of boiling water ½ a part each of picric acid and saltpetre are dissolved, and 15 parts of sawdust are impregnated with this solution. The impregnated sawdust is dried, and to every 10 parts thereof are added 17·5 parts each of nitrates of potash and soda, and 7·5 parts of sulphur. All the ingredients are finely powdered. Compressed sticks, or bars, of the same material are made by treating the material throughout in a damp state. (Spec. No. 4,155, 1. 12. 75).

HEUSSCHEN, *see* GLYCERO-NITRE.

HIMLY proposed a gunpowder in which hydro-carbons precipitated from solutions in naphtha take the place of the charcoal and sulphur of ordinary powder. The powder so made is said to be quite waterproof. (M., No. IV., p. 298).

JOHNITE consists of :—

Nitrate of potash	75 parts.
Sulphur	10 ,,
Lignite	10 ,,
Picrate of soda	3 ,,
Chlorate of potash	2 ,,

(*Mining Journal*, 18. 6. 87).

KÜP'S POWDER contains 80 per cent. of nitrate of baryta, with sulphur and charcoal.

LE BRICQUIR, *see* ESPIR.

LIESCH'S POWDER consists of saltpetre and coke dust.

LITHOFRACTEUR (nitrate mixture), *see* SAXIFRAGINE.

Lloyd, *see* Gallaher.

Lobb's Powder. In this powder sawdust is substituted for charcoal and sulphur in gunpowder, and lime is added. The object of the sawdust is to reduce the amount of smoke. The lime is added to counteract the deliquescent property of nitrates of soda or potash in gunpowder, especially in underground or damp situations. (Spec. No. 1,861, 25. 10. 61).

Matteen, *see* Pyrolithe.

Maxim proposed a mixture of

Nitrate of potash	74·18 parts.
Paraffin	11·42 ,,
Sulphur	10·40 ,,

He mixes one part of this with three parts of gunpowder to obtain a plastic cartridge. (Spec. No. 6,926, 8. 6. 85).

Miller's Powder consists of two compounds, which are harmless apart, and become explosive only when mixed.

No. 1 compound contains :—

Nitrate of soda	35 parts.
Saltpetre	25 ,,
Starch	2 ,,

No. 2 compound contains :—

Bichromate of potash... ...	3 parts.
Sulphur...	13 ,,
Charcoal	12 ,,

The proportions to form an explosive compound are 18 parts of No. 1 mixed with 7 parts of No. 2 (T., p. 106).

Murtineddu's Powders consist of mixtures of nitrate of soda (with or without saltpetre), with sulphur and various substances as tan, coal, sawdust, etc.

The mixture, patented in England, consists of :—

Saltpetre	100 parts.
Sulphur...	100 ,,
Sawdust	50 ,,
Horsedung	50 ,,
Sea salt...	10 ,,
Treacle	4 ,,

The object of adding the treacle is to give cohesion to the composition. It is claimed that "this composition does not cause explosion upwards as with gunpowder." (D., p. 608, and Spec. No. 2,403, 14. 10. 56).

Newton, *see* Saxifragine.

Nobel proposed a gunpowder for propelling purposes, composed of 80 parts of saltpetre, 6 parts, or less, of sulphur, and 14 parts of charcoal. To this was to be added, when desirable, to quicken its action (*a*) ordinary gunpowder, or (*b*) compressed guncotton, or (*c*) equal parts of nitrate of potash and picrate of ammonia, with the addition of a little gum. For blasting purposes the foundation was ordinary blasting powder, or that made with nitrate of soda, while the quickening agents were (*a*) equal parts of picrate of lead, or potash and saltpetre, with a little gum, or (*b*) gelatinised nitro-glycerine, or other known nitro-glycerine compound, or (*c*) compressed guncotton. He expressly bars the use of chlorate of potash powders as being too dangerous. (Spec. No. 226, 20. 1. 79).

OLIVER proposed to use peat in lieu of charcoal in gunpowder, and occasionally chlorate of potash, mixed with beeswax or tallow, and resin in lieu of sulphur. In this case the ingredients were to be mixed in a damp state. (Spec. No. 1,800, 10. 6. 69).

ORIENTAL POWDER consists of a mixture of tan, bark, sawdust or other vegetable fibre, impregnated with a nitrate or chlorate, and gunpowder or similar explosive compound. Spent tan is preferred (T., p. 100).

OXLAND'S POWDER consists of :—

Nitrate of soda	85 parts.
Sulphur...	16 ,,
Charcoal	18 ,,
Coal or dust (*sic*)...	20 ,,

The nitrate of soda is refined from the crude salt by precipitating the salts of lime and magnesia by carbonate of soda, and evaporating the filtered solution. (Spec. No. 1,740, 18. 7. 60).

PERALITE is a large grained powder consisting of :—

Saltpetre	63 parts.
Charcoal	30 ,,
Sulphide of antimony... ...	6 ,,

POCH, *see* PUDROLITHE.

PUDROLITHE, or ROCK POWDER, consists of :—

Saltpetre	68 parts.			
Sulphur...	12 ,,	or	Sulphur ... ... Powdered gumlac	8 parts. 3 ,,
Charcoal	6 ,,			
Nitrate of baryta...	3 ,,			
,, soda ...	3 ,,			
Sawdust	5 ,,			
Spent tan	3 ,,			

The nitrates of soda and baryta are dissolved in hot water and the tan and sawdust added to the solution and boiled

until dry. The other ingredients are then added, and the whole mixed together. The compound claims to be slow-burning, and to give but little smoke.

The manufacture of this explosive was carried on at a factory near Llangollen, but was abandoned a few years ago. (Spec. No. 656, 2. 3. 72).

PYROLITHE consists of :—

Saltpetre	51·5 parts.
Nitrate of soda	16·0 ,,
Sulphur	20·0 ,,
Sawdust	11·0 ,,
Charcoal	1·5 ,,

The inventor (Matteen) also patented another mixture, consisting of :—

Nitrate of soda	47 parts.
Saltpetre	18 ,,
Sulphur	17 ,,
Sawdust	12 ,,
Carbonate or sulphate of soda	6 ,,

The idea is to have no carbonic oxide in the products of combustion. (D., p. 106).

PYRONOME, *see* DE TRET, also a *chlorate mixture* under same name, p. 29.

PYRONITRINE was submitted to the French Government Commission in 1884, by M. Prodhomme. There were two samples, of the following compositions :—

	1	2
Nitrate of soda	35	18
Saltpetre	35	45
Tan	15	15
"Sulphate"	2	3
Sulphur	6	9
Charcoal	3	—
Resin	4	3
Tar	—	7

(Spec. No. 4,200, 15. 10. 80).

ROBERT'S POWDER. In this powder nitrate of soda is used wholly or partially in place of saltpetre in gunpowder. A proportion of anhydrous sulphate of soda (prepared by heating sulphate of soda), or of anhydrous sulphate of magnesia, not exceeding 18 per cent. of the nitrate of soda, is used therewith. (Spec. No. 139, 18. 1. 62).

ROCK POWDER, *see* PUDROLITHE.

SAFETY BLASTING POWDER (called also CARBO-AZOTINE) is licensed for manufacture in this country by Messrs. Pigou, Wilks, and Laurence (Ld.). In the license it is defined as a mechanical mixture of saltpetre, sulphur, lampblack, sawdust, and sulphate of iron. In the specification it is defined as consisting of :—

Nitrate of potash ,, soda ,, lime	one, two, or three nitrates	in all	50 to 64 parts.
Sulphur...			13 to 16 ,,
Tanner's bark (that containing refuse animal matter is preferred) or.. Sawdust, or Bark and sawdust			14 to 16 ,,
Soot or lampblack, or both...			9 to 18 ,,

and 5 to 6 parts of sulphate of iron to every 100 parts of the above mixture.

The materials are ground and boiled in a weak solution of sulphate of iron. The compound becomes liquid and then generally solidifies. When nearly solid it is dried.

This powder is issued occasionally in bulk, but more usually in the form of compressed cartridges like those made of gunpowder. It requires compression and confinement before it will explode.

It is recommended to be used as a wash, with about 10 gallons of water to 2lbs. of the compound, as a remedy for *phylloxera vastatrix.* (Spec. No. 3,934, 14. 11. 74).

In 1877 CAHUC took out a fresh patent for an improvement on his original powder as described above. He gave the following proportions as the best for blasting in various materials :—

	Hard rock.	Less hard rock and coal.	Bituminous coal and gypsum.
Saltpetre	70	64	56
Sulphur...	12	13	14
Lampblack	5	4	3
Spent tan or Sawdust	13	19	27
Sulphate of iron	2	2	5

He claims that these powders are equally powerful with those previously proposed, and safer to manufacture and use. (Spec. No. 4,732, 12. 12. 77).

SAXIFRAGINE consists of :—

Nitrate of baryta	77 parts.
Charcoal	21 ,,
Saltpetre	2 ,,

The nitrate of baryta is prepared by treating the chlorate of barium with nitrate of soda. The manufacture is identical with that of gunpowder. To increase the inflammability of the powder, the grains, while still damp, are dusted over with meal powder. (D., p. 610).

SCHÄFFER'S POWDERS consist of :—

Saltpetre	30 to 38 parts.
Nitrate of soda	40 ,,
Sulphur	8 to 12 ,,
Charcoal	7 to 8 ,,
Potassio-tartrate of soda (Rochelle salt) K Na $C_4 H_4 O_6$	4 to 6 ,,

It is a slow-burning powder. (Spec. No. 2,555, 19. 10. 63).

A subsequent specification gives :—

Potassio-tartrate of soda ...	4 parts.
Saltpetre...	78 ,,
Sulphur	8 ,,
Charcoal	10 ,,

SOULAGES, *see* SAFETY BLASTING POWDER.

TRIUMPH SAFETY POWDER, *see* COURTEILLE'S POWDER.

VIOLETTE'S POWDER consists of :—

Nitrate of soda	62·5 parts.
Acetate ,, ,, ...	37·5 ,,

The ingredients can be melted together so as to give a close combination, but if heated to about 660° F. the mixture explodes. It is hygroscopic. (B. II., p. 315).

WALKER, *see* GALLAHER.

WINDSOR'S POWDER consists of 25 parts of dry powdered sugar added to 100 parts of gunpowder. (Spec. No. 3,510, 4. 12, 11).

WYNANT'S POWDER. In this powder nitrate of baryta wholly or partially replaces the saltpetre in gunpowder. The following proportions are recommended :—

Nitrate of baryta	77 parts.
Charcoal	21 ,,
Saltpetre	2 ,,

(This is identical with saxifragine).

The nitrates of lead, or strontia, may replace the nitrate of baryta. The inflammability of the powder may be increased by dusting or coating the grains with ordinary fine powder. (Spec. No. 1,084, 15. 4. 62).

Experiments were made at Brussels with a powder in which $\frac{4}{5}$ of the saltpetre in gunpowder were replaced by nitrate of baryta. It was found to be unfit for small-arms on account of its slowness of combustion, and for larger arms on account of its fouling. It was consequently relegated to the rank of a blasting powder only. (D. p. 610).

Xanthine Powder consists of a mixture in which the sulphur and charcoal of ordinary powder are replaced by a compound containing them both, *e.g.*, xanthate of potash ($C_2 H_5 KCO S_2$), a compound prepared by adding to absolute alcohol an excess of pure caustic potash and of bisulphide of carbon. The proportion is:—

Saltpetre	100 parts.
Xanthate	40 ,,
Charcoal	6 ,,

(B. II., p. 315).

Class III.—(Chlorate Mixtures).

The employment of chlorate of potash in explosive mixtures has always offered great attractions, owing to the violence of its effects due to the rapidity of its action. Hence the number of proposed explosives in which this substance forms the main ingredient is extremely large, as will be seen on referring to the alphabetical list of them. At the same time they may, broadly speaking, be divided into two classes, those in which no particular attempt is made to diminish the dangerous sensibility of chlorate of potash compounds, and those in which by the addition of some diluting ingredient, or by some special mechanical treatment, endeavours are made to diminish this sensibility. Some of the compounds in the list appear to be simply more or less dangerous haphazard mixtures, while in other cases the same mixture of ingredients, or the same method of treatment, has with little, if any, variation, been proposed over and over again under different names. The objections to chlorate of potash compounds have been stated by several authorities.

For instance, Dr. Duprè, F.R.S., whose knowledge of explosives is exceptional in extent and minuteness, says:—"Chlorate of potassium, on account of the readiness with which it lends itself to the production of powerful explosives, offers a great temptation to inventors of new explosives, and many attempts have been made to put it to practical use, but so far with very limited success. This is chiefly owing to two causes. In the first place chlorate of potassium is a very unstable compound,* and is liable to suffer decomposition under a variety of circumstances, and under, comparatively speaking, slight causes, chemical and mechanical. All chlorate mixtures are liable to what is termed spontaneous ignition, or explosion in the presence of a variety of materials, more particularly of such as are acid or are liable to generate acid; and all chlorate mixtures are readily exploded by percussion, but more particularly by combined

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* "Chlorate of potassium is one of those compounds during the decomposition of which heat is evolved, or energy is produced during decomposition, instead, of, as is usually the case, being absorbed, and all such compounds are unstable"

friction and percussion, such as a glancing blow, which might easily and would often occur in charging a hole. In the second place there is some evidence to show that this sensitiveness to percussion and friction increases by keeping, more especially if the explosive is exposed to the action of moist and dry air alternately."*

The glancing blow referred to by Dr. Duprè is such as can be given with a slanting blow with a hammer on a plane or curved surface. Many chlorate mixtures which have been proposed for general use were found, on trial, to be so sensitive that they could be readily exploded by blows of this description with a light wooden mallet on a wooden floor, and almost all could be exploded with the same mallet on a stone floor.† The increased sensitiveness caused by keeping and exposure to moisture is probably due, in part at least, to the chlorate crystallizing out into fine crystals on the surface of the mixture.

Eissler, on the same subject, after referring to the fatal accident that attended the efforts of the discoverer of chlorate of potash, Berthollet, to utilize it in the manufacture of gunpowder, goes on to say :—" It is extremely doubtful from the peculiarities of this salt if anybody will ever overcome the obstacles due to its inherent chemical properties, which nature manifestly seems to have made unconquerable. In mixing these compositions great danger is attendant, and too much circumspection cannot be used. They explode instantly on any violent stroke, very often by friction alone ; sometimes spontaneously, as when in a state of rest, and no known cause for their combustion can be ascertained. Many are deluded as to its safety by so-called experiments with freshly-made powder. Manufacturers of the compound may attempt to show its safety by hammering and cutting it, and similar tests ; but let the powder be exposed to the natural atmospheric action, attract some moisture during the damp foggy night, then get dry, and the least friction or blow will cause an unexpected explosion. . . . . In ramming a cartridge well home in a bore-hole, the unsuspecting miner must either use blows or pressure, the latter being equally dangerous from the development of some friction. . . . ."‡

Berthelot§ remarks : "Les poudres au chlorate n'offrent donc pas à ce point de vue (strength) sur les nouvelles matières explosives une preponderance qui puisse compenser les dangers exceptionnels de leur fabrication et de leur manipulation. Ce n'est que comme amorces que leur facile inflammation peut offrir certains avantages."

Without going so far as to say that it is impossible to manufacture a safe chlorate mixture, it is a fact that out of many which have been examined with a view to their introduction into this country, not one has as yet been found to be safe enough to be licensed with the exception of asphaline*, but this explosive was not a practical success, inasmuch as its light and bulky nature required very large bore-holes in comparison with other explosives, and its manufacture and use in this country have been entirely abandoned.

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* Annual Report of H.M. Inspectors of Explosives for 1885, p. 31.

† This practically reproduces the conditions of a wooden rammer in a stone bore-hole.

‡ Eissler, p. 139.

§ B., Vol. II., p. 325.

Probably, also, the explosive papers such as *Melland's Paper Powder* and *Reichen's Rolls*† are fairly safe, but they have never, to my knowledge, come into practical use here, and the same objection of bulkiness in proportion to weight holds good with them as with asphaline.

I do not pretend to say that powerful and valuable explosives may not be, and have not been, manufactured with chlorate of potash as their main ingredient, but I contend that though these are fairly safe when used for special purposes and by experts, none have as yet been brought to notice (with the previously named exception) which are suitable for general use by the mining population, and which could be relied upon not to cause accidents under ordinary conditions of transport, storage, and use.

In some cases it has been proposed to keep the ingredients of chlorate of potash mixtures apart till required for use, and this principle has been carried out in the case of Rack-a-rock and other explosives, but this class will be more particularly dealt with in Class VII. (Sprengel Explosives), though some of them will be found also included in the list of the chlorate mixture class.

ASPHALINE consists of thoroughly cleansed wheat or barley bran, impregnated with chlorate of potash (in a proportion not exceeding 54 parts of chlorate to 42 parts of bran) mixed with saltpetre and sulphate of potash (in a proportion not exceeding 4 parts to 42 parts of bran). Paraffin oil, paraffin, ozokerit, and soap, or some of them may be added. The compound is coloured pink with fuchsine.

A variety of the above is called ASPHALINE No. 2, and consists of the above, with the addition of saltpetre in such proportion that the total amount of saltpetre present in the explosive does not exceed 25 per cent. These explosives were licensed for manufacture in a factory near Llangollen, previously used for the manufacture of Pudrolithe, but the manufacture has been abandoned.

The explosive is easily recognised by its bulkiness and resemblance to red or pink bran. (Spec. No. 2,488, 8. 6. 81).

AUGENDRE'S POWDER, known also as WHITE GERMAN or AMERICAN POWDER, consists of :—

Chlorate of potash	50 parts.
Yellow prussiate of potash ...	25 ,,
Cane sugar	25 ,,

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* *See* p. 20.

† *See* pp. 26 and 30.

The materials are moistened, mixed in bronze mortars, and granulated. (D., p. 614).

Baron and **Cauvet** submitted to the French Government Commission, in 1882, two powders, consisting of:—

	No. 1.	No. 2.
Chlorate of potash	50	50
Prussiate	50	25
Sugar	—	25

They are simply varieties of Augendre's powder.

Bellford's Powder consists of:—

Charcoal	19·5 parts.
Saltpetre	68·8 ,,
Sulphur	12·5 ,,

mixed, pressed, and granulated. The powder so produced is saturated with a saturated aqueous solution of chlorate of potash, dried at 100° F. for four days, and used unglazed. (Spec. No. 2,910, 15. 12. 53).

Bolton, Sir F., proposed a mixture of chlorate of potash, or other chlorate or nitrate with nitro-benzole or other solvent in which is dissolved a carbonaceous material, such as resin, molasses, etc. He proposed to make cartridges by filling bags with the solid constituent and then saturating them with the liquid, just as in the case of **Rack-a-rock**, *q.v.*

Bradbury, *see* **Harrison**.

Buckley, *see* **Harrison**.

Callow, *see* **Melville**.

Chanu, *see* **Davey**.

Clement, *see* **Fuchs**.

Cotter's Powder contains about equal parts of chlorate of potash and realgar.

Davey's Powders consist of:—

	1	2
Chlorate of potash	6 parts.	6 parts.
Nitrate ,, ,,	5 ,,	3 ,,
Yellow prussiate of potash	2 ,,	4 ,,
Bichromate of potash	2 ,,	— ,,
Sulphide of antimony	5 ,,	3 ,,

These compounds are chiefly intended for use as fuzes (Spec. No. 14,065, 15. 4. 52).

Davies Powder consists of:—

Yellow prussiate of potash	4 parts.
Chloride of potassium	8 ,,
Loaf sugar	2 ,,
Crystallized sugar	2 ,,
Sulphur	1 ,,

It was proposed as a powder for firearms. The ingredients were to be mixed together when fired, being previously finely powdered. (Spec. No. 824, 30. 3. 60).

DYNAMOGEN consists of :—

Yellow prussiate of potash ...	17 parts.
Water	150 ,,
Charcoal	17 ,,

These are boiled, well stirred, and allowed to cool. There are then added:—

Potash	35 parts.
Chlorate of potash	70 ,,
Starch	10 ,,
Water	50 ,,

The whole is made into a thin paste and brushed on to filtering paper, three coats being laid on each side. The paper so impregnated is dried, cut up, and rolled into cartridges. (Spec. No. 2,895, 19. 6. 82).

EHRHARDT'S POWDERS consist of :—

	For Artillery.	For Blasting.	For Shells.
Chlorate of potash... ...	1 part.	... 1 part.	... 1 part.
Saltpetre	1 ,,	... 1 ,,	... — ,,
Charcoal	— ,,	... 4 ,,	... — ,,
Tannic acid	1 ,,	... 2 ,,	... 1 ,,

(D., p. 613).

He also proposed a mixture of about equal parts of tannic acid or resin, and chorate or nitrate of potash, finely powdered. (Spec. No. 1,694, 8. 7. 64).

Also a mixture of the same ingredients in the proportion of one to three. The powders were to be placed in a flask with two chambers, and so kept separate till mixed in the act of loading. (Spec. No. 2,594, 20. 10. 64).

Also a mixture of :—

	For Blasting.	For Arms.
Chlorate of potash ...	1·5 parts (by bulk) ...	4 parts (by weight).
Nitrate of ,, ...	1·5 ,, ,, ...	— ,,
Cutch or tannin	1·0 ,, ,, ...	1 ,,
Cannel coal	2·0 ,, ,, ...	— ,,

(Spec. No. 402, 13. 2. 65).

ETNITE practically consists of ASPHALINE, with the addition of about 8 per cent. of sulphide of antimony.

EXPLOSIVE PAPER is much the same as DYNAMOGEN, and other similar explosives, consisting of rolls of paper impregnated with a chlorate mixture. The ingredients in this case are:—

Saltpetre...	5 parts.
Chlorate of potash	5 ,,
Charcoal or Powdered coal }	1 ,,
Fine hardwood sawdust	1 ,,

with a little gum for binding, and enough water to make a paste. (M., No. VII., p. 115).

Fenton's Powder consists of chlorate of potash, sugar, and yellow prussiate of potash in the proportions of four to eight ozs. of each of the latter ingredients to 16 ozs. of damp chlorate. The mixture is made in the form of a stiff dough, being damped with lime water, gum water, or water. It is dried in an oven, cut up with brass knives, and sifted into various sizes of grains. The powder can be coloured with various colouring matters, which it is apparently proposed also to use in lieu of sugar. It is claimed as suitable for all kinds of small arms and ordnance and for blasting purposes. (Spec. No. 4,148, 17. 22. 73).

Fléron de, *see* **Pertuiset.**

French Green Powder consists of :—

Chlorate of potash	14 parts.
Picric acid	4 ,,
Yellow prussiate of potash ...	3 ,,

Each ingredient is separately dried, and finely powdered, and the mixture is made in glass vessels, or, preferably, in wooden vats with wooden balls. (R.A.I. Proc., Feb. 1887).

Fuch's Powder consists of a mixture of chlorate of potash, finely ground tortoise or turtle shell, saltpetre, sulphur, and charcoal. (T., p. 101).

Garside, *see* **Harrison.**

Goetz' Powder is a mixture of an explosive base with glucose (grape sugar $C_6H_{12}O_6$), uncrystallizable sugar, or syrupy solution to prevent premature or accidental discharges. The proportions recommended are :—

Chlorate of potash	10 parts.
Solution of glucose	10 ,,
Charcoal in powder	3 ,,
Sulphur...	2 ,,
Amorphous phosphorus	1 ,,
Picrate of lead	3 ,,

It is claimed that the compound will stand all ordinary shocks, handling, and transport, without danger of explosion. It burns with a bright light when unconfined. (T., p. 105).

Gomez' Powders are mixtures of chlorate and prussiate of potash, with sugar (acetate) of lead, or nitrate of lead, or sugar of lead and nitrate of iron. (T., p. 101).

GRAHAM'S POWDER consists of :—

Yellow prussiate of potash ...	16	parts.
Chlorate	40	,,
White sugar	20	,,
Red lead	1·25	,,

It is claimed that the red lead obviates the danger of explosion, and that the compound can be used when wet and doughy. (T., p. 106).

HAFENEGGER'S POWDERS consist of the following compounds :—

	No. 1. parts.	No. 2. parts.	No. 3. parts.	No. 4. parts.	No. 5. parts.	No. 6. parts.	No. 7. parts.
Chlorate of potash	9 or 6	2	4	4	1	11	1
Sulphur	¼ ,, 1	—	1 (or sugar)	¼	—	¼	—
Charcoal	¼ ,, 4	—	¼	½	—	¼	1
Yellow prussiate of potash..	—	1	1	—	—	—	—
Sugar	—	1	1 (or sulphur)	4	1	—	—

He recommends for use with the above a self-igniting liquid consisting of solution of one or two parts of phosphorous in two of bisulphide of carbon, the time before explosion takes place being regulated by the amount of saturation of the powder with the liquid, the average period being about half-an-hour. He also proposes simply a mixture of chlorate of potash with the liquid. (Spec. No. 2,865, 17. 9. 68).

The danger and uncertainty of the propositions are obvious.

HAHN'S POWDER consists of :—

Chlorate of potash	367·5	parts.
Tersulphide of antimony ...	168·3	,,
Spermaceti	46·0	,,
Charcoal	18·0	,,

The idea is to add the chlorate of potash only when required for use, the mixing being done by sieves. The addition of the spermaceti is claimed to give safety against explosion by friction. (Spec. No. 960, 30. 3. 67).

HALL'S POWDER consists of :—

Chlorate of potash	47	parts.	
Ferrocyanide of potassium ...	38	,,	
Sulphur (or other chemical equivalent)	5	,,	(about)

The ingredients are pulverized and mixed in water, or "water and nitric acid." To the evaporated mixture are added 10 parts of caoutchouc, sometimes slightly impregnated with bisulphide of carbon. The whole is mixed, pressed, and granulated. (Spec. No. 1,062, 28. 4. 63).

Hannan proposed a mixture of yellow or red prussiate, nitrate, and chlorate of potash, with vegetable or animal charcoal. Paraffin or other oleaginous or fatty substance or gums are introduced as a binding material. (Spec. No. 4,846, 12. 10. 82 and No. 5,323, 8. 11. 82).

Subsequently he added ferric oxide to sharpen the explosion and render it local. (Spec. No. 5,986, 15. 12. 82).

Harrison's Powders consist of mixtures of saccharine matter with carbon, sulphur, clubmoss, and chlorate of potash. The following proportions are given :—

Chlorate of potash	7 parts, or for rifle shooting ...	11 parts.
Starch	1 ,, ,, ,, ,, ...	1 ,,
Charcoal	1 ,, ,, ,, ,, ...	1 ,,
Sulphur	1 ,, ,, ,, ,, ...	2 ,,
Clubmoss (lycopodium clavatum)	— ,, ,, ,, ,, ...	$\frac{1}{4}$,,
Coal	— ,, ,, ,, ,, ...	1 ,,
Soot from coal	— ,, ,, ,, ,, ...	$\frac{1}{2}$,,

(Spec. No. 2,642, 29. 10. 60).

Subsequent specifications give :—

Chlorate of potash ...	56 parts... ...	12 parts (or chlorate of soda)
Ferrocyanide of potash	28 ,, ...	4 ,,
Starch	4 ,, ...	2 ,,
Sulphur	7 ,, ...	— ,,
Charcoal	5 ,, ...	1 ,,
	Nitrate of potash ...	6 ,,

(or $2\frac{1}{2}$ parts of coal or cannel).

(Spec. Nos. 2,233, 6. 9. 61, and 305, 5. 2. 62).

Hochstätter's Compound consists of a mixture of chlorate of potash or of lead, nitrate of potash or of soda, and charcoal or sulphur, or a metallic sulphide. The mixture is dissolved in water, in which paper or vegetable matters are steeped so as to render them explosive. (Spec. No. 2,869, 17. 12. 69).

Horsley's Powder consists of a mixture of finely powdered chlorate of potash and gall nuts in the proportions of three to one. The powder is granulated by passing it through a sieve in a damp state. It is stated to explode at 430° F., and its force to be "five times that of gunpowder." (Spec. No. 1,193, 19. 4. 69, and No. 1,885, 22. 6. 72).—*See* also Class IV.

Jaline consists of :—

Nitrate of potash	65 to 75 parts.
Sulphur	10 ,,
Lignite	10 to 50 ,,
Picrate of soda	3 to 8 ,,
Chlorate of potash	2 ,,

Jolly, *see* Wigfall.

Kellow's Powders consists of :—

Nitrate of soda	30 parts or	36 parts.
,, potash	8 ,, ,,	4 ,,
Chlorate of potash	12 ,, ,,	6 ,,
Sulphur	10 ,, ,,	10 ,,
Tan and sawdust	46 ,, ,,	50 ,,

To each of the above receipts 30 quarts of water are added, and the compound mixed, dried and sifted. The proportions may be varied, greater strength being given by increasing the amount of chlorate of potash and diminishing that of the nitrate of soda. (Spec. No. 1,796, 17. 6. 62).

Knaffl's Powder consists of :—

Chlorate of potash	46 parts.
Nitrate of potash	26 ,,
Sulphur	15 ,,
Ulmate of ammonia	10 ,,

Ulmate of ammonia is a brown matter obtained by exposing a mixed cottton and wool fabric to the action of superheated steam. The cotton is untouched, but the wool forms a brown matter easily removed by a beating machine. It is usually sold for manure.

As might be expected from its composition, the above powder is very sensitive. (D., p. 612).

Köhler's Powder consists of :—

Chlorate of potash	70 parts.
Sulphur	20 ,,
Charcoal	10 ,,

Obviously a dangerously sensitive powder.
(Spec. No. 1,622, 10. 6. 57).

Macintosh proposed to mix gunpowder and other explosive compounds with indiarubber or guttapercha in a state of solution, and to spread the mixture on cloth, which becomes inflammable, burning rapidly if mixed with chlorate or nitrate of potash, and slowly if mixed with steel filings or sulphur. The cloth can be cut into strips and used in connection with incendiary projectiles. (Spec. No. 404, 11. 2. 57).

Melland's Paper Powder consists of unsized paper dipped into a boiling solution of the ingredients given below. The paper is then rolled into cartridges, and dried at 212° F. To protect the cartridges from damp they are coated with a solution

of one part of xyloidine (nitro-starch) in three parts of acetic acid. The ingredients are as follows :—

Chlorate of potash	9	parts.
Nitrate of ,,	4·5	,,
Ferrocyanide of potash	3·25	,,
Charcoal of potash	3·25	,,
Starch	$\frac{1}{21}$	,,
Chlorate of potash	$\frac{1}{16}$	,,

(D., p. 614).

This was patented in England by REICHEN. (Spec. No. 2,266, 2. 9. 65).

MELVILLE'S POWDERS consist of :—

	1	2	3
Chlorate of potash	2 parts.	5 parts.	1 part.
Red orpiment	1 ,,	2 ,,	— ,,
Prussiate of potash	— ,,	1 ,,	1 ,,

The ingredients are well mixed, damped, and moulded into cartridges for firearms or for mining purposes, or charging shells. (Spec. No. 13,215, 6. 10. 50).

MICHALOWSKI'S MINERS' POWDER consists of—

Chlorate of potash	50 parts.
Binoxide of manganese	5 ,,
Finely pulverised organic matter	45 ,,

The last ingredient is wood sawdust, tan, bran etc. The explosive much resembles ASPHALINE, *q.v.* (M. XIII., p. 244)

MONNIER'S POWDER consists of :—

Chlorate of potash	71 parts.
Sugar	16 ,,
Charcoal	6 ,,
Coal tar	7 ,,

The chlorate is dissolved in 250 parts of water, and freedom from danger is claimed for the wet process of manufacture. (T., 106).

MUNDELL, *see* PERTUISET.

NISSER'S POWDERS consist of :—

Yellow prussiate of potash	1·5
Bichromate ,, ,,	2·0
Perchlorate or chlorate of potash	10·5
Nitrates of soda and potash	44·5
Vegetable matter	6·5
Mineral and vegetable carbon	19·5
Sulphur	15·5

A more explosive powder for ordnance and firearms is made by using more of the potassium salts and less carbon and sulphur. (Spec. No. 1,939, 26. 7. 65).

He also proposed two inexplosive compounds to be kept apart till required for use, when their mixture formed an explosive.

No. 1 compound consisted of nitrate of potash or of soda mixed with perchlorate or chlorate of potash, or both, in proportions varying from 5 to 35 per cent. of each of these salts, according to the required strength of the powder.

No. 2 compound consisted of 25 to 35 per cent. of pure loaf sugar added to sublimed sulphur, and to these 8 to 10 per cent. of vegetable fibre or charcoal, or both.

The powder is stated not to ignite by friction or percussion (Spec. No. 1,375, 27. 4. 68).

He also proposed two compounds, consisting of chlorate of potash, 55 to 60 parts, bitartrate of potash 45 to 55 parts, ferrocyanide of potash, and coal. In the second compound the ferrocyanide of potash was replaced by sulphur. (Spec. No. 119, 14. 1. 70).

NOBLE'S POWDERS were submitted to the French Government Commission in 1880. Of these there were eight samples of the following compositions :—

	1	2	3	4	5	6	7	8
Chlorate of potash	100	100	100	50	100	100	100	100
Sugar	20	22	24	20	20	20	10	15
Prussiate of potash	16	18	22	8	—	8	16	16
Starch	1	—	—	2	2	2	2	1
Camphor	2	—	—	2	2	2	2	1
Sulphur	—	—	—	8	—	—	—	—
Benzoin...	—	—	—	—	16	8	—	—
Saltpetre	—	—	—	—	—	—	50	50
Charcoal	—	—	—	—	—	—	10	5

As might be expected they were dangerously sensitive. The addition of the camphor did not have the effect in diminishing the sensitiveness of the compounds containing it which it has in the case of guncotton and nitro-glycerine compounds.

PAINE, *see* DAVIES.

PARONE'S EXPLOSIVE consists of two parts of chlorate of potash to one part of bisulphide of carbon. It was tried in a 24 c.m. mortar in Italy, which burst at the first round. It is really a form of RACK-A-ROCK, *q.v.* (M. No. XV., p. 574).

PATTISON mixes chlorate of potash explosives with greasy vegetable flour or bran to lessen liability to explode. (Spec. No. 810, 24. 2. 80).

PELEY'S EXPLOSIVE PAPER consists of ordinary blotting paper soaked in the following mixture :—

Chlorate of potash	66 parts.
Yellow prussiate of potash ...	17 ,,
Refined salt	35 ,,
Wood charcoal	17 ,,
Starch	10 ,,

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the whole being mixed with 10 times its weight of boiling water. The paper is dried, cut into strips, and rolled into cartridges. (R.A.I. Proc., Feb. 1886).

Pellier's Powder was submitted to the French Government Commission in 1884. It consists of :—

Chlorate of potash	100 parts.
Saltpetre	$12\frac{1}{2}$,,
Sulphur	$12\frac{1}{2}$,,
Fine sawdust	9 ,,
Extract of logwood	15 ,,

It is practically the same as Kellow & Short's powder. The same inventor had previously, in 1882, submitted to the same Commission two similar powders composed as follows :—

	For blasting.	For guns.
Chlorate of potash	44 to 47	40
Yellow prussiate of potash	38 ,, 36	15
Flowers of sulphur	18 ,, 17	10
Sugar	—	10
Charcoal	—	5
Saltpetre	—	15

Both were of course extremely sensitive.

Pertuiset's Powder consists of :—

Chlorate of potash	2 parts.
Sulphur	1 ,,
Sporting gunpowder	$\frac{1}{8}$,,
Animal charcoal	$\frac{1}{50}$,,

It is recommended for use mainly as a detonating powder, or for filling bullets or shells. (Spec. No. 2,837, 9. 10. 67, and No. 2,066, 21. 7. 70).

Petry, *see* **Dynamogen.**

Pohl's Powder is almost identical with Augendre's. It consists of :—

Chlorate of potash	49 parts.
Yellow prussiate of potash	28 ,,
Cane sugar	23 ,,

(D., 615)

Prussian Fire, *see* **Wigfall.**

Pyronome consists of :—

Saltpetre	69 parts.
Sulphur	9 ,,
Charcoal	10 ,,
Metallic antimony	8 ,,
Chlorate of potash	5 ,,
Rye flour	4 ,,

together with a small quantity (a few centigrams) of chlorate of potash. The ingredients are boiled together, the mass evaporated down to a paste, dried, and powdered. (Spec. No. 3,923, 9. 9. 81).

Rack-a-rock consists of cartridges made of compressed chlorate of potash, which are dipped when required for use into certain liquids, which are by themselves, like the chlorate of potash, of an inexplosive character. The liquids are "dead oil," a dark heavy oil consisting chiefly of hydrocarbons derived from coal tar and having a high boiling point, or a mixture of dead oil with its own volumes of bisulphide of carbon, or a mixture like the last with the addition of about 3 per cent. of sulphur.

The chlorate of potash cartridges are enclosed in small bags of cotton, or other cloth of suitable size and shape, and dipped into the liquid. Preferably the mixture of dead oil and bisulphide of carbon is used, the object of the bisulphide of carbon being to prevent too large a proportion of dead oil from being taken up by the chlorate. The bisulphide afterwards evaporates out.

Nitro-benzol is also used as a dipping liquid, or as an ingredient thereof in combination with picric acid.

In practice the cartridges in a wire basket are suspended from a spring balance and dipped into a pail containing the fluid. The completion of the absorption of the proper amount of fluid is shown by the spring balance. The proportions given are 3 to $4\frac{1}{6}$ parts solid to 1 part liquid ingredient. See also *Sprengel Explosives*, p. 91.

Raves' Powder is a mixture of chlorate of potash and charcoal, or wood dust, or coal. The ingredients are made into a paste, dried and ground. The average proportions are given as 100 parts of vegetable matter or carbon to 200 parts of chlorate of potash. (Spec. No. 2,651, 23. 11. 59).

Reichen patented some rolls or cartridges of paper impregnated with a chlorate mixture identical with **Melland's Paper Powder**. (Spec. No. 2,266, 2. 9. 65).

Reveley's Powder consists of:—

Chlorate of potash	48 parts.
Yellow prussiate of potash ...	29 ,,
Loaf sugar	23 ,,

It is simply "White Gunpowder," the proportions of which, however, vary somewhat, those given in Bloxam's *Chemistry* being respectively two parts, one part, and one part of the the above-mentioned ingredients.

Augendre's and **Pohl's** are the same mixture, Augendre's answering to that given by Bloxam, Pohl's being identical with Reveley's.

Reynold's Powder consists of 75 per cent. of chlorate of potash with 25 per cent. of "sulphurea." It is a white powder, igniting at a lower temperature than gunpowder, and is easily made by the mixture of the two ingredients. "Sulphurea," it is said, can be prepared in large quantities from one of the waste products in gas manufacture. (T., 62).

Ricker's Powders consist of ten varieties of chlorate mixture containing a number of substances in addition to the chlorate of potash, such as charcoal, half calcined sea-grass, powdered coal, sawdust, nitrates of soda, lead, or potash, wheat flour, bicarbonate of soda, powdered bark, and dried coffee grounds. The ingredients are all boiled together in water. (Spec. No. 3,297, 9. 12. 62).

Roberts' Powder is White Gunpowder, made by a wet process, and kept in the form of a thin paste, to which a percentage of glycerine is added to prevent it from being dried. The mixture is exploded by detonating an initial charge of the powder (or other high explosive) in a dry state in contact with the pasty mass which forms the main charge. (Spec. No. 926, 14. 3. 73).

Rogers proposed a mixture of :—

Chlorate of potash	5 parts.
Cascarilla bark	2 ,,
Corundum	3 ,,
Indiarubber solution	3 ,,

for making blasting fuzes. The object of the corundum, or other non-inflammable ingredient, is to retard and regulate the burning. The compound was to be dipped in bisulphide of carbon, benzine, or other solvent to mix it. The solvent was evaporated, and the mass was ready for making coils or strands. (Spec. No. 1,356, 12. 5. 70).

Safety Gunpowder was proposed in 1888 for license in England. It consisted of a mixture of chlorate of potash and glycerine tinged pink. The ingredients, on keeping, separated more or less, and the mixture was rejected on account of its over-sensitiveness after some months' keeping.

Sandoy, *see* Pyromone.

Schlesinger's Powder consists of :—

Chlorate of potash	3 parts.
Sulphide of antimony	3 ,,
Flowers of sulphur	1 ,,

It was proposed for small arms. (Spec. No. 14,227, 20. 7. 52).

Sharp's Powder consists of :—

Saltpetre...	2 parts.
Chlorate of potash...	2 ,,
Yellow prussiate of potash... ...	1 ,,
Potash	1 ,,
Sulphur	2 ,,

(Spec. No. 2,779, 27. 10. 66).

Short, *see* **Kellow**.

Siemen's Powder is a mixture of saltpetre, chlorate of potash, and a solid hydrocarbon, such as paraffin, pitch, caoutchouc, etc. The compound is mixed by sieves, and then treated with a volatile liquid hydrocarbon. A plastic mass is produced, which is made into cakes, rendered hard by evaporating the solvent, and granulated. It is stated to be non-explosive when unconfined. (Spec. No. 1,969, 26. 4. 82).

Silesite (**Pietrowicz** and **Siegert**) consists of :—

Chlorate of potash	60 parts
Sulphide of antimony...	10 ,,
Sugar	30 ,,

Obviously a very sensitive compound.

Sleeper's Powder is a mixture of chlorate of potash, sugar, and charcoal.

Smith, *see* **Sharp**.

Spence, *see* **Ricker**.

Turpin's Powders consist of mixtures of 80 per cent. of chlorate of potash with 20 per cent. of coal tar and charcoal. In one variety about half the chlorate is replaced by nitrate of potash. Some absorbent of the nature of charcoal, silica, kieselguhr, etc., is added according to the degree of fluidity of the coal tar. The sensitiveness of the compound is increased by substituting 1 to 10 per cent. of permanganate of potash for an equivalent amount of the chlorate. Nitrate of lead may be substituted for saltpetre. (Spec. No. 2,139, 27. 4. 83).

Vril consists of (approximately) :—

	1		2
Chlorate of potash	50·0	... ...	48·0 parts.
Yellow prussiate of potash... ...	4·5	... ...	9·1 ,,
Nitrate of potash	25·0	... ...	24·3 ,,
Willow charcoal	12·5	... ...	11·6 ,,
Paraffin	6·0	... ...	6·5 ,,
Ferric oxide of potash...	2·0	... ...	0·5 ,,

(The latter variety is less sensitive than the first).

In external appearance it resembles ordinary gunpowder. It was proposed to be licensed as an authorised explosive, but failed to satisfy the requirements of safety.

Ward, *see* Graham.

Well's, *see* Hall.

White Gunpowder, *see* Augendre, Pohl, and Reveley.

Wigfall's Powder, or Prussian Fire, consists of (subject to variation) :—

Carbon	4 parts.	Phosphorus	4 parts.
Gums	4 ,,	Sulphur	2 ,,
Aquafortis	6 ,,	Chlorate of potash	26 ,,
Red lead	40 ,,	Sugar of lead	6 ,,
Cannel coal	1 ,,	Saltpetre	3 ,,
Steel filings	4 ,,		

It is doubtful from its very nature whether the above very heterogeneous and somewhat alarming compound was ever actually made. (Spec. No. 2,888, 18. 11. 63).

William's Powder consists of :—

Chlorate of potash	48 parts.
Prussiate of potash	16 ,,
Bichromate of potash	2 ,,
Nut galls	5 ,,
Cannel coal	2 ,,
Starch	6 ,,
Crude coal oil	5 ,,

Yates, *see* Harrison.

Zaliwsky proposed to mix chlorate of potash with oxalic acid before adding it to sulphur, charcoal or other ingredients. The object was safety in manufacture and manipulation. (D. p. 616).

CLASS IV.—(NITRO-COMPOUNDS CONTAINING NITRO-GLYCERINE).

We come now to the first division of a very important class of explosives, a class which has within the last two decades received a very considerable amount of attention and notoriety.

A nitro-compound may be defined as any chemical compound possessed of explosive properties, or capable of combining with metals to form an explosive compound, which is produced by the chemical action of nitric acid (whether mixed or not with sulphuric acid), or of a nitrate mixed with sulphuric acid, upon any carbonaceous substance, whether such compound is mechanically mixed with other substances or not.*

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* This is the definition given in Order in Council, No. 1, made under the Explosives Act, 1875, classifying explosives.

It will be seen that this is a wide-reaching definition, embracing a vast number of substances, ranging from nitro-glycerine to picric acid and nitro-benzole. It includes many substances which, under the definition given in the introductory chapter, are not ranked, at present at least, as explosives.

In the class at present under consideration will be included only those explosives which consist mainly, or in part, of nitro-glycerine, and which are generally called "dynamites."

Nitro-glycerine was discovered in 1847* by A. Sobrero, in the laboratory of Pelouze, to be produced by the action of a mixture of strong nitric and sulphuric acids upon glycerine. It was known as pyro-glycerine, and subsequently as glonoine or blasting oil.

It was formerly considered as a nitro-substitution compound, and the equation of its formation was given thus:—

$$\underset{\text{Glycerine.}}{C_3H_8O_3} \quad + \quad \underset{\text{Nitric acid.}}{3\,(H.\,NO_3)} \quad = \quad \underset{\text{Nitro-glycerine.}}{C_3H_5(NO_2)_3O_3} \quad + \quad \underset{\text{Water}}{3H_2O},$$

which represents it as formed from glycerine by the substitution of three molecules of nitric peroxide (NO_2) for three atoms of hydrogen.

But more recent researches have shown that nitro-glycerine should rather be regarded as the nitric ether of glycerine. This view takes glycerine to be the triatomic alcohol of the compound radical glyceryl (C_3H_5), to which alcohol nitro-glycerine $C_3H_5(NO_3)_3$ has the same relation as nitric ether ($C_2H_5NO_3$) has to ethylic alcohol ($C_2H_5.HO$).

Under these circumstances the equation of formation should be represented thus:—

$$C_3H_8O_3 + 3(HNO_3) = C_3H_5(NO_3)_3 + 3H_2O.$$

It will be noted that under both views the empirical formula of nitro-glycerine is the same, it is only the rational formula which is altered.

In the equations of formation no mention is made of the sulphuric acid, the presence of which is, however, essential in the production of the explosive. It takes, indeed, so far as we know, no active chemical part in the change, but is necessary to absorb the water which is formed in the process, and thus to keep the nitric acid up to its full strength and prevent its dilution, which would result in the formation of lower and weaker nitro-compounds of glycerine.

The only source, practically speaking, of nitro-glycerine on a commercial scale in this country, is the factory of Nobel's Explosive Co. (Ld.), at Ardeer, in the county of Ayr, and the following is a brief outline of the methed of manufacture:—A mixture of 1·2 tons of nitric acid (sp. gr. 1·5) with two tons of sulphuric acid (sp. gr. 1·84) is cooled down and run into a cooled leaden tank. Into

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* Some authorities say 1846.

this tank glycerine is injected in the form of fine spray till about 7·5 cwts. has entered the mixture. The temperature is very carefully watched, and never allowed to exceed a certain limit. The completion of this "nitrating" process is indicated by the fall of the thermometer due to the cessation of chemical action, and when the temperature has fallen to a certain point, the mixture of acids and nitro-glycerine is run off into another tank, where by virtue of the different specific gravities the nitro-glycerine (sp. gr. 1·6) separates in a short time, and floats on the top of the acids, whence it is drawn off, is well washed with water and with an alkaline solution to remove every trace of free acid, and is finally filtered into another tank ready for conversion into dynamite or similar explosive.

It is absolutely essential that the nitro-glycerine should be as pure as possible, free from all acid, and most especially from nitric peroxide (hyponitric acid, NO_2).

To attain this end, the ingredients must be pure, and the acids of the requisite strengths. The glycerine should be of 1·26 sp. gr. and free from lime, iron, and alumina, chlorides, and fatty acids. The presence of iron, alumina, or chlorine in any of the ingredients seriously interferes with the separation of the nitro-glycerine.*

By the chemical equation, for every 1lb. of glycerine, 2·47lbs. of nitro-glycerine should be furnished, but in practice the yield is only about 2lbs., the loss being accounted for by the supposition that in addition to the production of the strongest form of nitro-glycerine, other nitro-compounds are formed, some of which are subsequently washed away.

Another method of obtaining nitro-glycerine is the Boutmy process, which was carried on in the Pembrey factory in South Wales in 1882, but abandoned in consequence of a serious accident. This process consisted in making two separate mixtures, viz., one, the sulpho-glyceric of sulphuric acid and glycerine, and another, the sulpho-nitric of sulphuric and nitric acids, and finally mixing the two together. The system had some advantages, but had the very serious disadvantage of slow separation, a considerable portion of nitro-glycerine being thus kept for a prolonged period in contact with the acids, thereby giving rise to danger. The yield by this process is only 185 to 190 of nitro-glycerine from 100 of glycerine.†

Other processes have been tried, but the method employed at Ardeer is, I believe, that most in use for practical purposes. Nitro-glycerine is a heavy liquid (sp. gr. about 1·6) of an oily appearance, varying from a colourless condition when quite pure, to a yellow or brownish yellow in some samples of the article when manufactured on a commercial scale. It is of a very sweet taste and without odour. It is an active poison, and mere contact with it will, in most persons, induce violent sickness and a specially painful form of headache. As a rule, however, custom soon reconciles most constitutions to it, and the workers in factories of it, after a short time, handle it all day without feeling any ill effects whatever. It is used in minute doses as a medicine, or rather as a palliative, in cases of *angina pectoris*, and finds a place in the British Pharmacopœia as a recognised drug. It explodes when heated to about 360° F. or from a shock, but in small quantities it ignites and burns with some difficulty by the mere contact of flame.

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* The above description is condensed from a portion of a lecture delivered by Mr. G. McRoberts, F.C.S., the Works' Manager at Ardeer, on 25th April, 1883, and other points noted in this lecture will be also referred to in this chapter.

† D. p. 686.

When perfectly exploded, the resulting products are carbonic acid, nitrogen, water, and free oxygen, and may be represented thus :—

$$2\,C_3H_5(NO_3)_3 = 6\,CO_2 + 5\,H_2O + N_6 + O.$$

This excess of oxygen points to its profitable utilisation by mixing readily oxidisable substances with nitro-glycerine.

Imperfect combustion leads to the production of the poisonous carbonic oxide and nitrogen oxides, and hence the fumes of any nitro-glycerine compound, when simply burnt or imperfectly detonated, are far more dangerous than if the explosion be a perfect one.

The liquid freezes at about 40° F. as a rule,* though some samples freeze much less readily than others, possibly from their containing different nitro-compounds of glycerine. Once frozen it remains in this condition even when exposed for some time to a temperature sensibly exceeding its freezing point. When frozen it is very much less sensitive to a blow or to detonation than when liquid, and a detonator that will readily explode liquid nitro-glycerine, will simply scatter it when frozen. This holds good with most of the nitro-glycerine explosives, though there are some curious points of exception.

In a liquid state this explosive cannot be sold in, or imported into, this country. It is manufactured under the strict provision that it is forthwith made up into dynamite or some kindred licensed explosive.†

For many years after the discovery of nitro-glycerine, no practical use, except to a very limited extent as a medicine, was made of it, but between 1860 and 1863, Alfred Nobel, a Swedish engineer,

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* The S.G. of frozen nitro-glycerine is 1·735, *i.e.*, it contracts $\frac{1}{12}$th of its volume.

† In America only is liquid nitro-glycerine, so far as I know, still used. Mr. Mowbray manufactured and used large quantities for the boring of the Hoosac Tunnel, and has published a very interesting volume on the subject. It is used chiefly for oil-well torpedoes at present in that country, but there, as well as in other countries, the cheaper and safer dynamites have replaced this sensitive and dangerous liquid form of explosive.

whose name is indissolubly connected with, and pre-eminent in, the history of nitro-glycerine explosives, established factories on the Continent for its manufacture on a commercial scale as a blasting agent. But in the then state of knowledge, the new explosive was not a complete success; it was poisonous and dangerous to most people to handle, its liquid state rendered it dangerous to use and store, and it required strong confinement to even partially develop its power by simple inflammation. A great step was made when Nobel discovered the means of eliciting its enormous energy by the initial explosion of a detonator, which is simply a very powerful form of percussion cap. This marked a distinct epoch in the history of the explosive. In his English patent* he claims the ignition of the explosive by "the elevation of temperature produced by an electric wire, or by an initiative explosion or detonation produced in various ways, such as by a percussion cap or a small quantity of gunpowder."

Without going minutely into the point of what is meant by detonation, it may be stated that it denotes the almost instantaneous resolution of a substance, or mixture of substances, into other substances, mainly or entirely permanent gases, which occupy a volume far exceeding that of the original substance or substances. In the case of nitro-compounds, this detonation is effected by the combined action of a blow and heat, conveyed by the ignition of some very rapidly explosive and powerful substance placed as nearly as possible in contact with the substance to be detonated. Special explosives require special means of detonation, and it is curious that though an explosive *A* may detonate another explosive *B*, yet the action is not necessarily reciprocal, in that the explosive *B* will not necessarily detonate *A*. Sir F. Abel has shown that this holds good, at all events to a certain extent, with guncotton and nitro-glycerine.

The best and handiest method of detonation known for all nitro-compounds now in use, is to employ a stout metallic (usually copper) cap or detonator containing a charge of fulminate of mercury with, or without, the addition of chlorate of potash. The amount of the charge necessary to ensure detonation varies with the nature of the explosive to be detonated.

Returning to the history of nitro-glycerine; during the few years between 1863 and the finish of that decade, a succession of disastrous accidents due to liquid nitro-glycerine led to public reprobation of this dangerous and, to most people, mysterious and diabolical compound. Sweden, Belgium, and England (1869), totally prohibited its use, and Nobel's efforts and skill seemed destined to end in failure.

To make nitro-glycerine safer in transport † and storage, Nobel proposed to dissolve it in twice its bulk of methylic alcohol or wood spirit (CH_3HO), thus producing an inexplosive liquid. The spirit and nitro-glycerine were easily separated when the latter was required for use, by simply pouring the mixture into water and stirring it. The nitro-glycerine sunk to the bottom, and could be obtained in separate form by decanting off the superincumbent layer of spirit and water.

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* Spec. No. 1813, 20. 7. 64.

† Some at least of the catastrophes due to nitro-glycerine might have been averted had it not then been the practice to convey it in rigid metallic vessels. The danger of this was not then recognised, and another danger arose from the

There was some loss of nitro-glycerine in this process, which was at best but a cumbrous one, ill-adapted for general use in mining operations, and moreover the safety was apt to be illusionary, as the wood spirit is very volatile, and could evaporate freely from an imperfectly closed vessel.*

However, thanks to Nobel's energy and powers of invention, this method soon passed away as unnecessary, for in 1867 he at length produced dynamite, that is to say, a plastic mass consisting of nitro-glycerine absorbed in the pores of an inert material.

His English patent † is worth quoting at some length, as it not only marks the genesis of what has become an enormous manufacture, but more closely explains his views on the question of detonation. He says :—

"This invention relates to the use of nitro-glycerine in an altered condition, which renders it far more practical and safe for use. This altered condition of the nitro-glycerine is effected by causing it to be absorbed in porous unexplosive substances, such as charcoal, silica, paper, or similar materials, whereby it is converted into a powder, which I call dynamite, or Nobel's safety powder. By the absorption of the nitro-glycerine in some porous substance, it acquires the property of being in a high degree insensible to shocks, and it can also be burned over fire without exploding." ‡

He then speaks of the means of firing it, and goes on to say :—

"From the aforesaid it will be understood that a strong fulminating cap, if adapted to the fuze by being squeezed thereon, will cause dynamite to explode under all conditions of confinement or non-confinement. . . . . . It is evident that the above described

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universal belief that when frozen, the liquid was much more sensitive than in its unfrozen condition. The belief was effectually dispelled from the mind of Mr. G. M. Mowbray, then the largest manufacturer of nitro-glycerine in America, by the failure of nitro-glycerine to detonate on an occasion when it had been accidentally upset in the snow in the winter of 1867-8. From that date he invariably sent out all his nitro-glycerine in a frozen state. But the belief died hard elsewhere.

* Another proposition, also by Nobel, was to dilute nitro-glycerine with half its weight of tar oil to render it inexplosive. When required for use 150 parts of the above mixture are shaken up with 100 parts of oleic acid, the latter dissolves the tar oil, setting free the nitro-glycerine. (Spec. No. 5,252, 28. 4. 85).

† Spec. No. 1,345, 7. 5. 67.

‡ As will be seen hereafter, this is true in a limited sense only.

fulminating cap may be greatly varied in form, but the principle for its action lies in a sudden development of a very intense pressure or shock."

Here then we have at last dynamite produced, and that name now stands as a generic title for a vast number of nitro-glycerine explosives, known individually under various distinguishing or fancy names. They may be conveniently divided into two great classes:—

1. Dynamites with an inert base acting merely as an absorbent for the liquid nitro-glycerine.
2. Dynamites with an active, that is to say an explosive or combustible, base.

This second class may be sub-divided into three minor classes, viz., those which contain as a base :—

(*a*). Charcoal.
(*b*). Gunpowder, or other nitrate or chlorate mixtures.
(*c*). Guncotton, or other nitro-compounds.

Of Class 1, ordinary dynamite No. 1 may be taken as an example.

Of Class 2, dynamite No. 2, lithofracteur, and blasting gelatine may be taken as examples respectively of the sub-classes, *a*, *b*, and *c*.

If it is desired to ascertain whether a given substance contains nitro-glycerine, the following are rough and ready tests :—If a liquid is oozing out or can be squeezed out from the substance, put the drop on to blotting paper. If this is nitro-glycerine it will make a greasy stain, not disappearing or drying away ; struck with a hammer on iron a loud report will be heard ; lit and burnt, it will give a crackling sound and a greenish flame. If gradually heated by a flame underneath, it will give a sharp report.

Again, put a portion of the substance into a test tube and shake it up with methylic alcohol (wood spirit), first ascertaining that the spirit poured into water causes no turbidity or milky appearance. Filter the contents of the tube into another tube, and add pure water to the latter. If nitro-glycerine is present, a milky appearance will be produced, and the heavy liquid will eventually settle at the bottom of the tube.

A much more delicate test is to use aniline and concentrated sulphuric acids as re-agents. In the presence of nitro-glycerine a purple colour is produced, which changes to green on the addition of water.

Nitro-glycerine explosives, unless carefully made from pure ingredients, are apt to decompose spontaneously. Any indication of acid fumes, or any tinge of green in them, should be followed by their prompt destruction, with suitable precautions.

In the following alphabetical list the typical varieties of the dynamites will be described at some length, while the minor members of the same class will be briefly noted :—

ABEL, *see* GLYOXILINE.

ÆTNA POWDER is an American dynamite containing from 15 to 65 per cent. of nitro-glycerine, with wood pulp of nitrate of sodium.

AMIDOGÉNE, *see* AMMONIA DYNAMITE.

AMMONIA DYNAMITE has several times been proposed for use as a powerful explosive, and no doubt it can lay claim to this designation. It essentially consists of nitro-glycerine mixed with nitrate of ammonia. Under the name of AMMONIAKKRUT it was introduced by Ohlson and Norrbin. Their form of this explosive consisted of finely powdered dry nitrate, or nitrite, of ammonia, intimately mixed with from 5 to 10 per cent. of its weight of powdered charcoal, coal dust, or other combustible substance. To the mixture was added 10 to 30 per cent. of nitro-glycerine. Picrate of potash, or nitro-mannite, were named as substitutes for the nitro-glycerine, but the latter was preferred on account of its liquid condition. (D. p. 721. T. pp. 91 and 102. Spec. No. 2,766, 18. 9. 72).

In 1873 the British Dynamite Co. (now Nobel's Explosives Co.), submitted samples of ammonia dynamite to the Special War Office Committee on Guncotton, etc. These samples contained respectively :—

	1	2
Nitrate of ammonia	75	70
Paraffin	4	7
Charcoal or coal dust	3	10
Nitro-glycerine	18	13

They were accompanied by three other samples of much the same composition, save that in two of them nitrate of soda was used in place of nitrate of ammonia, and in the third, nitrate of potash took its place.

The Committee reported against the samples containing nitrates of ammonia and soda on the ground that, owing to the deliquescent nature of these salts, considerable exudation of nitro-glycerine might occur under the ordinary conditions of transport and storage. They reported in favour of the sample containing nitrate of potash (report of Spec. Com. on Guncotton, etc., 1871 to 1874, p. 96). The only feasible remedy against the danger here pointed out appears to be the enveloping of each individual cartridge in some absolutely waterproof covering.

AMMONIA GELATINE. This explosive generally resembles the one last named, and is open, with some modifications, to the same objection. It consists of 40 parts of a thin blasting gelatine, *q.v.*, containing 97·5 parts of nitro-glycerine to 2·5

parts of nitro-cotton, incorporated with 55 parts of nitrate of ammonia, and 5 parts of charcoal. It is a black, somewhat moist-looking mass, more friable than blasting gelatine, and less so than ordinary dynamite.

Though a powerful and stable explosive, it is open to the same objection which has hitherto barred the introduction of ammonia dynamite, that is to say, the liability of the deliquescent nitrate of ammonia to flow away in a liquid form, leaving only the thin blasting gelatine which would, from its physical characteristics, have a tendency to exude from an ordinary cartridge and form a source of danger. The explosive would in fact become a blasting gelatine "liable to exudation or liquefaction." The remedy would be to make every cartridge absolutely waterproof, but as yet this has not been done in this country on a commercial scale.

AMMONIAKKRUT, *see* AMMONIA DYNAMITE.

AMMONIC POWDER, *see* AMMONIA DYNAMITE.

ASBESTOS POWDER is a combination of nitro-glycerine with asbestos as the absorbent. Other powders, such as gunpowder, white gunpowder, nitro-cellulose, etc., may be mixed with the compound, or with the asbestos alone. A portion of the latter may be replaced by clay, plaster, infusorial silica, chalk, etc. (T. p. 101).

ATLAS POWDER is a mixture of nitro-glycerine with wood pulp or (in some grades) sawdust. Nitrate of sodium is usually added. The percentage of nitro-glycerine varies from 75 to 10 per cent. according to the brand. It is manufactured by the Repauno Chemical Company, Philadelphia, U.S.A., and is mainly known in England from its use in various attempted Fenian outrages. The following are examples of its composition :—

	A	B
Sodium nitrate	2	34
Wood fibre...	21	14
Magnesium carbonate ...	2	2
Nitro-glycerine...	75	50

BLASTING GELATINE. This essentially consists of a combination of nitro-glycerine and nitro-cotton. It is manufactured by dissolving finely divided nitro-cotton, the soluble form of which is chiefly employed in nitro-glycerine, heated to a point (about 100° F.) below that at which it begins to decompose. As nitro-glycerine contains an excess, and nitro-cotton a deficiency, of the oxygen requisite for the complete combustion of the carbon contained in them, blasting gelatine, by combining the two, compensates for the respective surplus and defect of available oxygen.

Two varieties are licensed in this country, viz., *No. 1*, which is defined as "nitro-cotton* . . . . combined with thoroughly purified nitro-glycerine in such proportions that the whole shall be of such character and consistency as not to be liable to liquefaction or exudation."

No. 2 is simply *No. 1*, with the addition of a nitrate, with or without charcoal.

The No. 1 is that practically in use. It is a gelatinous mass, looking something like new honey in colour, varying in consistency from a tough leathery material to a soft one, like ordinary stiff jelly. These variations depend on a variety of circumstances, such as the chemical condition of the nitro-cotton, and certain other details of manufacture. It contains from 93 to 95 per cent. of nitro-glycerine, and is issued in cartridges like dynamite. Speaking broadly, the thinner the gelatine the more sensitive it is to detonation, but on the other hand, a thin gelatine is more liable to liquefaction, and possibly also to exudation, and thus to cause danger in storage and transport. Specially strong detonators are required to explode blasting gelatine, or ordinary detonators with a primer of dynamite or gunpowder. It requires confinement to develop its detonative power, or rather its power of transmission of detonation, for a train of it cannot be exploded in the open (unlike dynamite) except by means of a very powerful initial detonation. The addition of a small percentage of camphor or other substances soluble in glycerine and rich in carbon and hydrogen, as benzole or nitro-benzole, renders it very insensible to explosion by shock or blow, and hence more difficult to detonate. While dynamite and nitro-glycerine in a frozen state are much less liable to be exploded by a blow, such as that given by a rifle bullet, than when unfrozen, the reverse holds good with frozen blasting gelatine.

Some recent accidents tend to show that considerable care should be exercised in charging bore holes with wholly or partly frozen gelatinous compounds of nitro-glycerine. No undue force or friction should be permitted, even with a wooden rammer.

This explosive has the great advantage of being, unlike dynamite, practically entirely unaffected by water, and so can, if desirable, be kept under water like wet guncotton. It is on the whole less liable to freeze than dynamite.

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* Consisting of nitro-cellulose carefully washed and purified.

These properties, combined with its great strength, due to the increased proportion of nitro-glycerine and the use of the explosive nitro-cotton instead of the inert and non-carbonaceous kieselguhr, render it a formidable rival to ordinary dynamite. It is moreover more cleanly to use, and, from its physical condition, small portions are not so liable to be broken off the main cartridge by accident and to fall into places where their presence may constitute a serious hidden danger.

It is most essential that the greatest care be taken in the manufacture of blasting gelatine, otherwise it is apt to seriously deteriorate and even to decompose altogether in store, but when well made, and from pure ingredients it appears to be a safe and stable explosive.

It is issued in cartridges and packed like Dynamite No. 1, *q.v.*

BORLAND, *see* CARBO-DYNAMITE.

BRADY, *see* VULCAN.

BRAIN'S POWDERS consists of 40 to 50 per cent. of nitro-glycerine mixed with 60 to 50 per cent. of other substance, as chlorate of potash, sugar, charcoal, ground coal, sawdust, dextrine, starch, and shumach. The last named substance consists of the ground shoots of the *Rhus Coriaria*, and contains a large proportion of tannic acid. It is used in tanning morocco leather. The following are examples of these powders, 40 to 50 per cent. of nitro-glycerine being added in each case :—

	1	2	3	4	5
Chlorate of potash ...	15	1	1	1	1
Charcoal or sawdust ...	10	1	2	1	1[*]
Ground coal	5	1	—	—	1[†]
Sugar	—	—	—	1	—
Saltpetre...	—	—	—	—	1

(Spec. No. 2,984, 11. 9. 73.)

BRODERSEN, *see* GLYOXILINE.

BURSTENBENDER impregnates soft, spongy, elastic vegetable substances, such as cellulose, pith, fungi, etc., with glycocoll or chondrin, and then mixes them with 20 to 60 per cent. of nitro-glycerine. The advantages claimed are non-liability to exudation up to 200° and freedom from freezing at temperatures below zero. It is stated that these properties are due to the glycocoll or chondrin present. The explosive is granulated through sieves.

[*] Sawdust, dextrine, starch, or shumach.

[†] Ground coal or charcoal.

Chondrin is obtained from animal substances, and is very closely allied to gelatine. Glycocoll is obtained by the action of acids on gelatine, and is a crystalline organic base. (T. p. 105.)

CARBO-DYNAMITE is a form of dynamite patented by Mr. W. D. Borland, and recently submitted for examination with a view of its being placed on the list of authorised explosives. The result of the examination was favourable. The explosive consists of 90 parts or less of nitro-glycerine to 10 parts of a very absorbent charcoal, obtained by carbonising cork. To every 100 parts of the explosive, 1½ parts of carbonate of sodium or of ammonium may be added. In one variety water is added with the view of rendering the dynamite uninflammable or nearly so. This dynamite does not disintegrate or exude when exposed to the action of water. It is a black somewhat friable substance. The patentee claims that by the addition of 3 to 5 parts of his carbonised cork (in lieu of an equal amount of kieselguhr) to ordinary dynamite, the latter also becomes capable of resisting the action of water. (Spec. No. 758, 18. 1. 86.)

CASTELLANOS POWDERS are of two sorts. The first consists of nitro-glycerine with the addition of nitro-benzole, fibrous material, and pulverised earth. It is claimed that the addition of the nitro-benzole allows the nitro-glycerine to burn easily and rapidly without explosion and renders it less liable to freeze.

The second powder consists of nitro-glycerine, with nitrate of potash or soda, a picrate, sulphur, and a salt insoluble and incombustible in nitro-glycerine and carbon.

The incombustible salts may be silicates of zinc, magnesia, and lime, oxalate of lime, carbonate of zinc, etc. The object of the inert salt is to render the nitro-glycerine less sensitive and safe. The following proportion is suggested :—

Nitro-glycerine	40	parts
Nitrate of potash, or soda ...	25	,,
Picrate	10	,,
Sulphur	5	,,
Insoluble salt (as above) ...	10	,,
Carbon	10	,,

(T. p. 103.)

CHAMPION POWDER, an American dynamite identical or nearly so with JUDSON'S POWDER.

CLARKE'S EXPLOSIVE is called in the specification glycero-pyroxiline, and is produced by treating textile or other vegetable fibre impregnated with glycerine with the usual acids. The idea

is to get a compound of a more homogeneous character than a mixture of nitro-glycerine with pyroxiline. (Spec. No. 3,408, 10. 11. 68).

Coad's Explosive is a mixture of nitro-glycerine with saltpetre and naturally decayed wood. There are several grades, of which the three following are examples :—

	1	2	3
Nitro-glycerine	75	30	30
Saltpetre	5	50	—
Naturally decayed wood	20	20	10
Ordinary blasting powder	—	—	60

(T. p. 104.]

Colonia Powder consists of a mixture of common blasting powder with 30 to 40 per cent. of nitro-glycerine. It has been manufactured at Cologne by Wasserfuhr, Bros. (D. p. 721, T. p. 88).

Dahmen, *see* **Safety Dynamite.**

Dean's Explosive consists of :—

Powdered nitro-cellulose or nitro-dextrine ...	10 parts
Water	2 to 3 ,,
Nitro-glycerine	100 ,,

The idea is to make the nitro-glycerine safer to handle and transport by forming a pasty mass. (Spec. No. 2,226, 21. 5. 81).

Deissler *see* **Kuhnt.**

Diaspon-Gelatin (Johann Anders) consists of 92 to 95 parts of nitro-glycerine mixed with 5 to 7 parts of "slightly nitrated" wood cellulose or collodion wood, and 0·5 to 2·0 parts of alcohol. The ingredients are placed in a water bath at 40° to 45° C. with 10 to 15 parts of a solvent composed of 6 parts of ether to 2 parts of alcohol. The nitro-cellulose is dissolved, and the ether, with the added alcohol, evaporates. (Spec. No. 80, 24. 2. 81).

Diaspon (Johann Anders) consists of :—

Nitro-glycerine	47 to 63 parts
Nitro-cotton	0·5 to 3·0 ,,
Nitrate of soda	22 to 23 ,,
Wood cellulose	8 to 18 ,,
Sulphur	3 to 9 ,,

(Spec. No. 81, 24. 2. 81).

Dittman proposes to render the transport and storage of nitro-glycerine safer by mixing it with a porous combustible substance, such as finely divided wood charcoal saturated with a solution of saltpetre or nitrate of soda and with a solution of carbonate of soda. Or the nitro-glycerine may be mixed with nitro-cellulose, or sawdust, or nitrated woody matter. (Spec. No. 3,458, 5. 12. 67).

DITTMAR, *see* DUALINE, and GLUKODINE.

DUALINE consists of :—

Nitro-glycerine	50	parts
Fine sawdust	30	,,
Saltpetre	20	,,

but various mixtures of the same kind are made under the same title ; the sawdust is sometimes nitrated. Dittmar's patent speaks of a mixture of cellulose, nitro-cellulose, nitro-starch, nitro-mannite, and nitro-glycerine. The cellulose is prepared from soft woods, treated with dilute acids, and then boiled in a solution of soda.

Dualine is said to be liable to exudation. The commercial variety is a yellowish brown powder. It is said to be more sensitive than ordinary dynamite to heat and friction. Owing to the excess of carbon the gasses evolved on explosion contain a large proportion of the poisonous carbonic oxide. (D. p. 726. T. pp. 87 and 100. Spec. No. 3,088, 3. 9. 75).

Another variety was patented by Schultze (Spec. 2,542, 14. 8. 68), and consists of a mixture of from 10 to 60 lbs. weight of nitro-glycerine with 100 lbs. of wood gunpowder, the proportion being varied according to the purposes for which the explosive is required. It is also prepared with an admixture of small grains of wood or powdered charcoal impregnated with a nitrate.

DYNAMITE No. 1. This is the ordinary dynamite of commerce, as used in this country. It is an admixture of nitro-glycerine with a porous infusorial earth called *kieselguhr*, which consists mainly of silica. Beds of it are found in Germany, Scotland, and elsewhere. It is calcined to drive off water and organic matter, and more or less of the accompanying sand is sifted away. It generally contains a little iron, which accounts for the more or less red tinge observable in ordinary dynamite. A little carbonate of ammonia or soda is usually added to the dynamite, so that its aqueous extract is alkaline.

Till 1887 this explosive was licensed in the following terms :—

"*Dynamite No. 1*, consisting of not more than 75 parts by "weight of thoroughly purified nitro-glycerine, uniformly "mixed with 25 parts by weight of an infusorial earth

"known as *kieselguhr*, and sufficiently absorbent in quality " when mixed in the above proportions to prevent exudation " of nitro-glycerine."

The above definition is now slightly altered, so as to include not only a simple mixture of nitro-glycerine and *kieselguhr* but also a mixture containing small quantities of other substances. The definition now runs thus :—

" *Dynamite No. 1*, consisting of not more than 75 parts ' by weight of thoroughly purified nitro-glycerine, uniformly ' with 25 parts by weight of :—

" (*a*) An infusorial earth known as *kieselguhr*, or,

" (*b*) A non-explosive mixture of *kieselguhr* with such " other ingredients and in such proportions as " may for the time being be sanctioned by the " Secretary of State ;

Provided :—

" (1) That the said (*a*) *kieselguhr*, *or* (*b*) non-explosive " mixture, shall be sufficiently absorbent in " quality when mixed in the above proportions " to prevent exudation of nitro-glycerine ; and

" (2) That there may be added to the *kieselguhr* or " non-explosive mixture an amount of carbonate " of ammonium not exceeding 1½ parts by " weight in every 100 parts by weight of the " finished dynamite."

The ingredients at present sanctioned under (*b*) are :—

Carbonate of sodium	In all 8 parts (or less) by weight in substitution for an equal amount by weight of *kieselguhr*.
Sulphate of barium	
Mica	
Talc	
Ochre	

Provided that the total amount of carbonate of sodium present shall in no case exceed three parts by weight in every 100 parts by weight of the finished dynamite.

Dynamite is a plastic mass varying in colour from buff to reddish brown. The direct contact of water disintegrates it, separating the liquid nitro-glycerine, and hence great caution is requisite in using it in wet places. In this particular it compares unfavourably with blasting gelatine and gelatine dynamite. As a rule it freezes at about 40° F. and remains frozen at temperatures considerably exceeding that point. In this condition it is practically useless as a blasting agent, and requires to be thawed or "tempered." This operation requires great care, and the instructions issued with every packet should be closely and carefully attended to.*

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* *See* Addendum to the chapter.

When ignited in comparatively small quantities it simply burns away fiercely, but fatal accidents have arisen in considerable number from persons supposing that, as it is reasonably safe to ignite a few cartridges of unfrozen dynamite, it is equally safe to warm it upon a shovel, in an oven, in a tin over a fire, or in various other ways which usually lead to a verdict of "Accidental Death."*

It cannot be too strongly impressed that if dynamite or other nitro-glycerine preparations are gradually warmed up to a temperature approaching their exploding point (about 360° F.) they become extremely sensitive to the least shock or blow, and once that point is reached they do not simply ignite but explode with great violence.

Frozen dynamite has some peculiar properties as distinguished from unfrozen dynamite, which have been experimentally shown and may be summarized as follows.

(1) It is considerably less sensitive to a blow, or to the impact of a projectile. A rifle bullet fired into unfrozen dynamite readily explodes it, but a bullet from a Martini-Henry rifle fails to do so at 25 yards range. Blasting gelatine on the other hand is more sensitive to similar treatment when frozen.

(2) It is much more susceptible to explosion by simple ignition. For instance, so small an amount as 1 lb. has been exploded by ignition when frozen, while very considerably larger quantities of the unfrozen material will burn away without explosion.

(3) Like frozen nitro-glycerine, it is much less sensitive to detonation.

Dynamite is almost invariably issued in cylindrical rolls, of a diameter suitable to the bore holes in which it is to be used, and these rolls are wrapped in parchment paper to form cartridges. Five pounds of cartridges make a packet, and ten packets go to a box, which thus contains 50lbs. of dynamite.

Blasting gelatine and gelatine dynamite are issued in the same way.

DYNAMITE No. 2 is milder and slower than No. 1, and was introduced to compete with gunpowder where the great power and local shattering effect of No. 1 was undesirable, for instance in coal mines, and slate and granite quarries. It is issued like No. 1, but is easily distinguished by its black colour. It is, however, little, if at all, now used in this country.

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* The verdict in such cases should be suicide or manslaughter, as the case may be.

In the License it is defined as follows :—

"*Dynamite No. 2*, consisting of not more than 18 parts by weight of thoroughly purified nitro-glycerine, uniformly mixed with 82 parts by weight of a pulverised preparation, composed of nitrate of potassium 71 parts, charcoal not less than 10 parts, and purified paraffin (*or* ozokerit) 1 part (*or* nitrate of potassium 72 parts, and charcoal not less than 10 parts) by weight, and sufficiently absorbent in quality when mixed in the above proportions to prevent exudation of nitro-glycerine."

Dynamite au Charbon, proposed by Nobel, is of two kinds, to either of which sulphur may be added. The compositions are as follows :—

Nitrate of baryta	68 parts	70 parts
Charcoal	12 ,,	— ,,
Resin	— ,,	10 ,,
Nitro-glycerine	20 ,,	20 ,,

It is practically much the same as Dynamite No. 2. (D., p. 720).

Dynamite blanche de Paulilles is much the same as Dynamite No. 1, being composed of 70 to 75 per cent. of nitro-glycerine mixed with 30 to 25 per cent. of a natural silicious earth. (D., p. 702).

Dynamite d'ammoniaque, *see* Ammonia Dynamite.

Dynamite de Boghead consists of 60 to 62 per cent. of nitro-glycerine mixed with carefully cleansed and powdered ashes of Boghead mineral. The ash consists of a mixture of silica and alumina.

Dynamit de Trauzl, *see* Trauzl.

Dynamite, E.C., is identical with the old definition of Dynamite No. 1, except that carbonate of soda (not exceeding 3 per cent.) is added.

Dynamites grises de Paulilles are mixtures of 20 to 25 per cent. of nitro-glycerine with nitrate of soda and resin, with or without charcoal. They are therefore much the same as Dynamite au Charbon. (D., p. 721).

Dynamite de Krümmel is a sort of dualine. The composition consists of :—

	No. 1.	No. 2.
Nitro-glycerine	48 to 50 parts	30 to 35 parts
Dried and nitrated sawdust	10 ,,	60 ,,
Kieselguhr	40 ,,	5 ,,

They are brownish in colour. The weaker mixture is designed for use in coal and other soft materials. (D., p. 726).

DYNAMITE NOIRE is a mixture of powdered coke and sand with about 45 per cent. of nitro-glycerine. It is said to be more dangerous than ordinary dynamite. (D., p. 719).

DYNAMITE ROUGE consists of 66 to 68 per cent. of nitro-glycerine absorbed in tripoli, a very finely divided silica. (D., p. 702).

DYNAMITE, S 1, is identical with DYNAMITE, E.C.

DYNAMITES DE VONGES consists of :—

	No 1.		No. 2.		No. 3.		Special.	
Nitro-glycerine	75		50		30		90	
Randanite *	20·8	25	—		—		1	10
Silice de Vierzon	3·8		48	50	—		—	
Sub-carbonate of magnesia	0·4		—		—		1	
Meudon chalk	—		1·5		—		—	
Red ochre	—		0·5		—		—	
Silice de Launois	—		—		60	70	—	
Blast furnace slag... ...	—		—		4		—	
Carbonate of lime ...	—		—		1		—	
Yellow ochre...	—		—		5		—	
Silice spéciale	—		—		—		8	

(D., p. 701).

DYNAMITE DE ZANKY, *see* DYNAMITE DE KRÜMMEL.

DYNAMAGNITE, *see* NITRO-MAGNITE.

ENGELS has proposed some rather complicated explosives consisting of :—

Pyroxiline	5 to 10 per cent.
Nitro-glycerine	60 to 70 ,, ,,
Pyro-papier	15·5 to 18 ,, ,,
Nitro-starch	0·5 ,, ,,
Nitro-mannite	5 to 1 ,, ,,
Nitro-benzole	0·5 ,, ,,
Ammonium salts (nitrate, sulphate or chloride) ...	10 to 30 ,, ,,
Water glass	0·5 ,, ,,
Saltpetre	8 to 10 ,, ,,

They thus appear to be a jumble of all sorts of nitro-compounds with the addition of nitrates. (M. No. XIII., p. 246).

EXTRA POWDER is a variety of Giant Powder manufactured in three grades from which it differs in containing a proportion

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* A silicious material like kieselguhr found in the neighbourhood of Ceyssat (Puy-de-Dôme), and attributed to the decomposition of felspar by natural acidulated mineral waters.

of nitrate of ammonium. The hygroscopic qualities of this salt are neutralized by coating it with crude vaseline before mixing it with the other ingredients.

FAHNELJELM, *see* SEBASTINE.

FITCH, also REUNERT, proposed a mixture consisting of 10 parts of nitro-glycerine to 90 parts of an absorbent composed of 73 parts of nitrate of soda, 12 parts of charcoal, 10 parts of sulphur, and 5 parts of starch. It is a sort of nitrate mixture with a little nitro-glycerine added. (Spec. No. 7,497, 22. 5. 88).

FORCITE has been described as a mixture of nitro-glycerine with cellulose, the latter being gelatinised by heating in water under considerable pressure. The American patent terms it a combination of nitro-glycerine with "an inexplosive gelatinizing material and an oxidating salt." Samples however examined in England consisted of a thin blasting gelatine with which were incorporated nitrate of potassium, wood meal or pulp, and a little dextrine; practically, in fact, it was a gelatine dynamite containing dextrine. Other samples contained nitro-glycerine, nitro-cotton, nitrate of sodium and charcoal. A variety manufactured in America consists of a thin blasting gelatine incorporated with a mixture consisting of 3 parts of sulphur to 20 parts of wood tar and 77 parts of nitrate of sodium. To this mixture one per cent. of wood pulp is added to counteract the sticky qualities of the tar, while the latter is said to prevent the thin blasting gelatine from soaking into the base, which is thus used as a carrier rather than as an absorbent.

The proportion of nitro-glycerine varies with the grade. It generally resembles gelatine dynamite in properties and appearance. It was invented by Capt. J. M. Lewin of the Swedish service, and was submitted for licensing in this country, but rejected for want of chemical stability. (Spec. No. 4,943, 27. 11. 80).

FOWLER'S EXPLOSIVE consists of a mixture of 20 parts of nitro-glycerine, 5 parts of charcoal, and 75 parts of an absorbent composed of 75 parts of nitrate of ammonia and 25 parts of anhydrous sulphate of soda. The last ingredient is prepared from sulphate of ammonia and nitrate of soda by a double decomposition. The object is to obtain a cheap combination of nitrate of ammonia in which the latter does not deliquesce. (T., p. 105.)

FULGURITE consists of nitro-glycerine mixed with some coarsely ground farinaceous substance, preferably corn meal, in varying proportions. It is claimed that the meal being nearly pure starch, the large volume of gas yielded on explosion assists the nitro-glycerine. (T., p. 102).

FULMINATINE is a mixture of as much as 85 per cent. of nitro-glycerine with a substance "prepared by a chemical process." Burnt in the open it leaves a slight residue rich in carbon. (D., p. 728).

GELATINE DYNAMITE is one of the most recently introduced nitro-glycerine explosives in this country. As its name implies, it occupies a place mid-way between blasting gelatine and dynamite. It consists of a thin blasting gelatine mixed with other substances. Two varieties are licensed: No. 1 contains cotton, charcoal, or "such other ingredients as may for the time being be sanctioned by a Secretary of State;" No. 2 consists of No. 1 mixed or incorporated with nitrate of potash or other nitrates. The varieties practically in use contain nitro-glycerine, nitro-cotton, nitrate of potash, and wood meal. They resemble blasting gelatine very closely in appearance, and it requires practice to distinguish them apart. Both come under the No. 2 class and differ in grade only. One contains about 80, the other 60 per cent. of explosive. The last named is known as gelignite.

GELIGNITE, *see* above.

GIANT POWDER is a term loosely used as a synonym for dynamite, but the explosive made in California under this name is essentially a lignin-dynamite containing nitrate of sodium. *See* also "EXTRA."

GIANT POWDER No. 2 consists of 40 per cent. of nitro-glycerine added to a mixture of 40 parts nitrate of soda or potash, 6 parts rosin, 6 parts sulphur, and 8 parts of infusorial earth. Other nitrates may be substituted for those above named, and other carbonaceous substances for the rosin. It is practically Dynamite No. 2.

There are in all seven grades of giant powder containing from 75 to 20 per cent. of nitro-glycerine.

GIRARD employed sugar as an absorbent for nitro-glycerine; also Millot and Vogt.

GLONOINE, an early name for nitro-glycerine.

GLUKODINE is a whitish liquid produced by the nitration of a saturated solution of cane sugar in glycerine. Free sugar

dissolves in it, and is soluble in ether. Two sorts of glukodine powder are made, white and black. Samples showed the following composition :—

	White.	Black.
Matter soluble in ether (glukodine) ...	36·40	34·24
Free sugar	8·40	8·76
Soda salts (mostly nitrate)	31·20	37·84
Nitro-cellulose	23·36	—
,, ,, and charcoal	—	19·31

Another analysis of the same samples showed that the glukodine in the white powder consisted of 33·19 parts of nitro-glycerine to 3·21 parts of nitro-saccharose, and in the black powder of 30·23 and 4·03 parts of the same ingredients respectively. Subsequent experiments appeared to show that glukodine was simply a mechanical mixture of those ingredients, as the nitro-glycerine could be readily evaporated off from the nitro-saccharose. (M. No. II. p. 445, *et seq.*)

GLYOXILINE consists of nitrated guncotton impregnated with nitro-glycerine, and is due to Sir F. Abel, C.B. A similar material was submitted by Mr. Brodersen for license in 1885 and approved, but no steps have since been taken for its introduction. (Spec. No. 3,652, 24. 12. 67, and D. p. 725.)

GOTHAM'S EXPLOSIVE consists of :—

Chlorate of potash	10 parts
Nitrate ,, ,, ...	2 ,,
Powdered oak bark	5 ,,
Nitro-glycerine	30 to 35 per cent.

(T., p. 105.)

GREEN absorbs nitro-glycerine in a mixture of kieselguhr and charcoal or carbonized starch, and claims that the dynamite so made will not exude in water.

GOTTHEIL, *see* RHENISH DYNAMITE CO.

HECLA POWDER, an American form of lignin-dynamite made in seven grades, containing from 75 to 20 per cent. of nitro glycerine, with the addition of nitrate of sodium.

HEICK, *see* THUNDER POWDER.

HERCULES POWDER, an American form of dynamite containing from 75 to 20 per cent. of nitro-glycerine. It is made in ten grades of which two are constituted as follows :—

	No. 1.	No. 2.
Carbonate of magnesia	20·85	10·00
Nitrate of potash	2·10	31·00
Chlorate ,, ...	1·05	3·34
White sugar	1·00	15·66
Nitro-glycerine	75·00	40·00

(T., p. 103).

Some varieties consist of wood pulp, nitrate of sodium, carbonate of magnesium, and nitro-glycerine. Another variety is called No. 1 EXTRA HERCULES POWDER, and is identical with NITRO-MAGNITE, *q.v.*, containing 80 per cent. of nitro-glycerine to 20 per cent. of magnesia alba.

HILL'S POWDER consists of a mixture of nitro-glycerine and a siliceous powder prepared by precipitation from a solution of silicates.

HINDE proposed an explosive consisting of :—

Nitro-glycerine	64	parts
Ammonium citrate ($C_6H_7(NH_4)O_7$) ...	12	,,
Ethyl palmitate ($C_{18}H_{36}O_2$)	0·25	,,
Calcium carbonate	0·25	,,
Sodium	0·50	,,
Coal	23	,,

(M. No. V., p. 731.)

HORSLEY'S POWDERS consisted of :—

(1) The admixture of three parts of nitro-glycerine with eight parts of alum or sulphate of magnesia, finely powdered and sifted.

(2) The addition of 20 per cent. of nitro-glycerine to his chlorate of potash and nut gall powder. (*see* HORSLEY in chlorate mixture section.)

Two varieties were licensed about 1872, and specified as containing nitro-glycerine thoroughly mixed with not less than 75 per cent. of one of the following powders, pulverized or granulated :—

	A	B
Chlorate of potash	3 ...	6
Nut galls	1 ...	1
Wood charcoal	— ...	1

JUDSON DYNAMITE is a mixture of nitro-glycerine, nitrate of sodium and bituminous coal. The percentage of nitro-glycerine is small.

JUDSON POWDER is an American form of dynamite made in four grades, containing from 5 to 20 per cent. of nitro-glycerine. It is a mixture of nitro-glycerine with various explosive salts, but differs from the usual form of such mixtures in that the grains of the absorbent are coated with some combustible substance offering resistance to the absorption of nitro-glycerine or water. The object is "to save and render "effective that proportion of nitro-glycerine which with "ordinary absorbents is so closely absorbed and taken up "that it is rendered practically inexplosive." Hence a com-

paratively very small proportion of nitro-glycerine will, it is stated, give a powerful explosive compound. The following is given as an example of such an absorbent :—

Sulphur	15 parts
Resin	3 ,,
Asphalt	2 ,,
Nitrate of soda	70 ,,
Anthracite	10 ,,

The three first ingredients are melted together and well stirred, and the nitrate of soda and coal, dried and powdered, are stirred in till thoroughly mixed, the stirring to be continued gently till the grains cease to adhere to each other. The nitro-glycerine can be added to the finished mixture as desired. (T., p. 105.)

The composition of the R.R.P. grade, the one most commonly used, is :—

Sodium nitrate	64 parts
Sulphur	16 ,,
Cannel coal	15 ,,
Nitro-glycerine	5 ,,

Practically this is a sort of crude gunpowder, containing a little nitro-glycerine. It requires a primer of more powerful explosive to develop its full powers.

Jupiter Powder, a name given to a No. 2 Dynamite, similar to **Vulcan** or **Neptune Powder**.

Kraft is a sort of dynamite introduced by C. J. Bjorkmann, and consists of :—

Nitro-glycerine	62 parts
Chlorate of potash	19 ,,
Nitrate ,, ,,	17 ,,
Ground cork	14 ,,

Kuhnt and **Deissler** mix nitro-glycerine with carbonate or chloride of ammonium, and claim that the temperature of the gases evolved on explosion is so low as to prevent flame.

Lewin, *see* **Forcite**.

Lignin-dynamite is a generic name for mixtures of nitro-glycerine with sawdust or wood pulp, whether nitrated or not. In some forms nitrates are also added.

Lignose, a synonym for **Lignin-Dynamite**.

Lithofracteur is a sort of Dynamite No. 2. As imported into England, it consists of not more than 55 parts of nitro-glycerine mixed with 45 parts of a pulverised preparation consisting of one part of charcoal, bran, and sawdust, (singly or in combination), 3½ parts of kieselguhr, 2½ parts of nitrate of baryta and bi-carbonate of soda (or either of them) and ½ part of sulphur and manganese (or either of them). Other analyses have given :—

	A	B
Nitro-glycerine	52	70
Kieselguhr and sand	30	23
Powdered coal	12	2
Nitrate of soda	4	—
,, ,, baryta	—	5
Sulphur	2	—

It is inferior in explosive power to Dynamite No. 1, and is said to be more sensitive to heat. To all intents it is a mixture of ordinary dynamite with a crude sort of gunpowder. Though on the list of authorised explosives it is now rarely used in this country.

MAGNESIA POWDER, *see* HERCULES POWDER No. 1.

MATAGNITE was submitted in 1888 for approval, but rejected in the case of one sample for chemical impurity and exudation, and in the case of another, for exudation. It consisted of nitro-glycerine, nitrate of potash and nitro-cellulose.

MATAZIETTE was manufactured at Fabry near Geneva. It consisted of a mixture of about 40 per cent. of nitro-glycerine with sand, ochre, coarsely pounded charcoal and resinous matter. In October, 1877, twelve casks, containing in all about three tons of this material, were seized by the French douaniers at Pontarlier, an attempt having been made to pass it as manure. It was removed to the fort of Larmont for safe custody. The casks cracked and allowed the contents to escape, and after three months it was decided to re-pack the explosives into boxes lined with sawdust. The work was half done when an explosion took place, killing six and wounding four men, and doing considerable amount of structural damage. The accident was due to rash and rough handling of the explosive by inexperienced men.

MEGANITE (Schückher & Co.) is of three kinds :—

		Nitro-cellulose.		
	Nitro-glycerine.	Wood.	Vegetable ivory nuts.	"Added powder."
No. 1	60	10	10	20
,, 2	38	6	6	50
,, 3	7	9	9	75

The "added powder" for No. 1 is nitrate of soda ; for No. 2, 75 parts of nitrate of soda to 1 of soda and 24 of wood meal ; for No. 3, as for No. 2, except that rye meal takes the place of wood meal. See also ORIASITE.

Metalline Nitroleum is a mixture of nitro-glycerine with pulverised red lead, with or without plaster of Paris.

Mica Powder is a mixture of nitro-glycerine with finely divided scales of mica, and is due to Mowbray. It is claimed that the mica scales, which replaced the thin flakes of glass originally tried, act as carriers rather than absorbents of the liquid explosive. The principle involved is the same as that enunciated by Judson, *q.v.*, namely that a proportion of nitro-glycerine is practically lost in ordinary absorbents such as kieselguhr. But the mica scale will only retain 52 per cent. of nitro-glycerine as compared with the 75 per cent. of ordinary dynamite. The mica powder is said to be quicker in action than ordinary dynamite. (T., p. 88).

Millot, *see* Girard.

Miner's Friend Powder is a lignin-dynamite containing nitrate of sodium.

Miner's Powder Company Dynamite is a No. 2 dynamite, practically identical with Vulcan Powder.

Monakay's Explosive. To every pound of a mixture composed of equal weights of ashes, lamp-black, earth, nitrate of soda, and borax, half a gill of kerosene oil is added. To this compound nitro-glycerine is added in quantities varying according to the strength desired. It is claimed that the kerosene, a fluid hydro-carbon, dilutes and modifies the nitro-glycerine so as to diminish the risks of accident, and that it acts beneficially in adding to the strength of the compound when exploded. (T., p. 106).

Morse's Explosive consists of nitro-glycerine and resin dissolved in a common solvent. The latter is evaporated and the explosive compound formed into a hard, dry, solid, granulated, or pulverised mass. (T., p. 107).

Neptune Powder, an American dynamite of the No. 2 type, practically identical with Vulcan Powder, Vigorite, etc.

Nitro-Glycerine, *see* introduction to this section.

Nitroleum, an early name of nitro-glycerine.

Nitrolite (C. Lamm) consists of :—

Nitro-glycerine	99	to	94	parts
Nitro-cellulose (cotton, starch or straw nitrated)	1	,,	6	,,
Nitrate of ammonia, soda, or potash, and light charcoal	50	,,	150	,,

Nitro-benzole is said also to be present. It is stated that the above is liable to exudation and is very hygroscopic.

NITRO-MAGNITE or DYNA-MAGNITE consists essentially of nitro-glycerine absorbed in magnesia alba (a mixture of hydro-carbonates of magnesia). It was approved for manufacture in the United Kingdom in 1879, but, owing to the then existing Nobel patents, which were held by a decision of the House of Lords to include all explosives of the dynamite class, no steps were taken to establish a factory. It was brought forward by Mr. E. Jones of Caerphilly, and appeared to promise well "as the power of magnesia alba to absorb ". . . . nitro-glycerine appears even superior to that of "kieselguhr, while the volume of gas generated by the "detonation of nitro-magnite may be a little larger, in con-"sequence of the expulsion of carbonic acid from the magnesium carbonate at the high temperature to which it is exposed."[*]

This explosive is employed in America under the name of HERCULES POWDER, *q.v.*

NOBEL has proposed to use a mixture of metallic salts rich in oxygen, *e.g.*, nitrate, chlorate, or perchlorate, with one of the nitro-compounds of glycerine, sugar, or cellulose. The barium, potassium, and sodium salts are mentioned, and for blasting operations, a mixture of from 75 to 80 per cent. of one of these with 20 to 25 per cent. of nitro-glycerine is recommended. For fire-arms he proposes the addition of 5 to 15 per cent. of nitro-glycerine, or 10 to 30 per cent. of nitro-glycerine thickened with nitro-cellulose or nitro-sugar, or cellulose alone. (M. No. XIII., p. 246.)

See also introduction to this section.

NORRBIN, *see* AMMONIA DYNAMITE.

OHLSON, *see* AMMONIA DYNAMITE.

ORIASITE is the same as MEGANITE, *q.v.*, except that nitrated wood stuff alone is used, the use of vegetable ivory being abandoned.

PALEINE, *see* STRAW DYNAMITE.

PETRALITHE consists of :—

Nitro-glycerine	640	parts	
Nitrate of ammonia, soda, or urea	120	,,	
Palmitinate of cetyl	2½	,,	(the principal part of the solid portion of spermaceti.)
Carbonate of lime	2½	,,	
Prepared vegetable or animal charcoal...	230	,,	
Bi-carbonate of soda	5	,,	

[*] Abel on Explosive Agents. Proc. of C.E., Vol. LXI., 1879-80. (Spec. No. 3,954, 8. 10. 78.)

This somewhat curious mixture was proposed for adoption in England in 1882, and was patented, but no active steps were taken for its introduction. (Spec. No. 2,302, 25. 5. 81).

This compound as submitted to the French Government Commission was stated to consist of :—

Nitro-glycerine	60	parts
Nitrate of potash, soda, or ammonia	16	,,
Spermaceti	1	,,
Carbonate of lime	1	,,
Lignin	6	,,
"Special" charcoal	16	,,

(Spec. No. 2,149, 25. 5. 80).

PORIFERA NITROLEUM is a mixture of nitro-glycerine with sponge or vegetable fibre, with or without the addition of plaster of Paris.

POTENTIA, an American form of dynamite of the No. 2 type. (T., p. 88.)

PUNSHON'S EXPLOSIVE is a mixture of nitro-glycerine with carbonized or charred peat as an absorbent, in the proportion of 70 parts of nitro-glycerine to 30 of peat. The nitro-glycerine "is cleaned by means of chalk mixed with water "instead of by the use of alkalies . . . . When as much "nitro-glycerine has been absorbed by the peat as it is "capable of holding, finely ground guncotton may be added "in such proportion as will ensure the detonation of the "prepared nitro-glycerine at a temperature at which ordinary "nitro-glycerine would rarely explode." This last paragraph is rather obscure, looking at the respective exploding points of nitro-glycerine and guncotton. (Spec. No. 4,268, 9. 12. 75.)

RENDROCK is a mixture of an alkaline nitrate with nitro-glycerine, wood-fibre and paraffin, or similar substance. The suggested proportions are :—

Nitrate of potash	40	parts
Nitro-glycerine	40	,,
Wood-fibre	13	,,
Paraffin (or pitch)	7	,,

with or without the addition of small quantities of sulphur and charcoal. (T. p. 101.)

REUNERT *see* FITCH.

RHENISH DYNAMITE CO. This company, through Robert Gottheil, proposed in 1874 to employ in place of pure nitro-glycerine a compound consisting of a solution of a hydro-carbon in nitro-glycerine. Napathaline is recommended as suitable.

The solution is prepared by dissolving 2 to 3 per cent. of napthaline in nitro-glycerine under the action of heat in a water bath, or by mixing a small quantity of kieselguhr saturated with melted napthaline with the nitro-glycerine and other substances forming the explosive compound.

Two mixtures are suggested, viz:—

Washed infusorial earth (*i.e.* kieselguhr) ...	23 or 20 parts
Chalk	2 ,, 3 ,,
Heavy spar	— ,, 7 ,,
Solution of napthaline in nitro-glycerine ...	75 ,, 20 ,,

The advantages claimed are somewhat curiously expressed:—"The nitric acid (*sic*) contained in the nitro-"glycerine is completely utilized, as a chemical combination "of the hydro-carbon with the nitro-glycerine is thereby "effected instead of a mere mechanical mixture of the nitro-"glycerine with an organic substance, as in compounds "heretofore employed. ... ..." (Spec. No. 1,566, 4. 5. 74).

Rhexite is a mixture of nitro-glycerine, wood-fibre, and saltpetre, somewhat similar to Atlas Powder. It is made by the Borkenstein Company in Styria.

Rutenberg's Explosive is simply dynamite made with randanite* instead of kieselguhr. (Spec. No. 360, 30. 1. 73).

Safety Dynamite. Glycerine is mixed with a nitrated hydrocarbon, preferably of the benzole series, 3 per cent. or upwards of the latter being used. The compound is nitrated in a mixture of 2 parts sulphuric to 1 part of nitric acid, being cooled during the process by the introduction of nitrogen. The resulting product is washed in an alkaline solution at 50° C. and mixed with kieselguhr. Safety in manufacture and against concussion is claimed, and also non-liability to freeze. (Prov. Spec., 3. 12. 88).

Safety Nitro-Powder is an American lignin-dynamite containing nitrate of sodium, and in the lower grades some starch.

Schultze in 1868 proposed to mix 10 to 60 pounds weight of nitro-glycerine with 100 lbs. of his wood gunpowder. *See* Dualine. (Spec. No. 2,542, 14. 8. 68).

Sebastine consists of :—

Nitro-glycerine	78 or 68 parts
Charcoal	14 ,, 20 ,,
Saltpetre	8 ,, 12 ,,

The charcoal is to be as porous and inflammable as possible. (D., p. 720 and Spec. No. 4,075, 21. 10. 76).

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* *See* Dynamite de Vonges.

SELENITIC POWDER is a mixture of nitro-glycerine with plaster of Paris. (T., p. 100).

SERANINE is a mixture of nitro-glycerine and chlorate of potash. (D., p. 722).

SHAEM, *see* SCHULTZE.

STRAW DYNAMITE is a mixture of nitro-glycerine with nitro-cellulose made from straw. It is termed PALEINE. *See* also Lanfrey's Powder in guncotton section. (Spec. No. 3,119, 7. 8. 78).

THUNDERBOLT POWDER, an American form of dynamite of the No. 2 type. (T., p. 88).

THUNDER POWDER consists of honey and glycerine treated with nitric and sulphuric acids. The product is mixed with chlorate of potash, nitrate of potash, prepared sawdust, and prepared chalk in two proportions for two different grades. (T., p. 107).

TITAN POWDER, an American form of dynamite of the No. 2 type. (T., p. 88).

The same name is also given to another explosive of the guncotton class.

TRAUZL'S DYNAMITE is a mixture of nitro-glycerine and guncotton pulp. One sample consisted of :—

Nitro-glycerine	75 parts
Guncotton	25 ,,
Charcoal...	2 ,,

This compound is stated to have been detonated by a strong detonator after being four days under the water and containing 15 per cent. of moisture. (D., p. 725).

VIGORITE* consists of about :—

Nitro-glycerine	30 parts
Nitrate of soda	60 ,,
Charcoal..	5 ,,
Sawdust (or partly nitrated wood or paper pulp) ...	5 ,,

Another brand as manufactured by the California Vigorite Powder Co., consists of :—

Nitro-glycerine	43·75 parts
Nitrate of potash	18·75 ,,
Chalk...	8·75 ,,
Sawdust	11·25 ,,
Chlorate of potash	17·50 ,,

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* The same name was formerly applied to a nitro-compound not containing nitro-glycerine.

The presence of the deliquescent nitrate of soda renders this a specially dangerous mixture, for the salt melts readily when exposed to damp, and the nitro-glycerine consequently exudes. A serious accident was occasioned by vigorite made by the Hamilton Powder Company on the 5th May, 1879, when a consignment of it, described as blasting powder, exploded on the Grand Trunk Railroad at Stratford, Ontario, while the cars were being shunted. Two men were killed and several injured, while 24 cars were destroyed and 100 damaged.

VIRITE was proposed for licensing in the United Kingdom in 1882. There were two kinds, of which No. 1 consisted of a mixture of nitro-glycerine, nitrate of potash and charcoal. This was favourably reported on as far as regarded its safety. No. 2 contained nitrate of sodium in place of nitrate of potash, and as might have been expected (*see* VIGORITE) failed to retain its nitro-glycerine under conditions which might well arise during ordinary transport, and it was therefore unfavourably reported on.

VOGT, *see* GIRARD.

VULCAN POWDER is of the following approximate composition :—

Nitro-glycerine	30	parts
Nitrate of soda	52·5	,,
Sulphur...	7	,,
Charcoal	10·5	,,

It is much the same as Vigorite or Virite No. 2. It was largely used in the first Hellgate explosion at New York, 11,852 lbs. of it being used in conjunction with 9,127 lbs. of rendrock and 28,935 lbs. of dynamite. (D., p. 721, and *Abel on Explos. Agents*, p. 26).

There is also a lignin-dynamite containing nitrate of sodium manufactured under this name.

WARREN'S POWDER consists of one part of nitro-cellulose added to 10 parts of nitro-glycerine. The mixture is allowed to stand until the nitro-cellulose is dissolved without heat. Pulverized tri-nitro-cellulose is mixed in till the mass is brought to the consistency of a dry powder. Add pressed and glazed gunpowder, the proportion varying with the strength required. A proportion of 70 parts gunpowder to 30 parts of the above mixture is suggested. "One of the main objects "of this compound is to keep the added gunpowder dry." (T., p. 106).

WETTER DYNAMITE (Müller and Aufschläger). The principle of this is the incorporation of salts having a high proportion of

water of crystallisation with dynamite, so as to be safe for use in fiery mines. (Spec. No. 12,424, 13. 9. 87).

A mixture of 40 per cent. of soda crystals with dynamite or of alum with gelatine dynamite may be used. Soda with gelatine dynamite gives a substance as hard as stone, and cannot therefore be used.

The French Committee at Sevran-Livry, in 1888, tried various mixtures. Amongst them were equal weights of dynamite and soda crystals, or sulphate of soda, or ammonia alum, or ammonium chloride. They stated that a temperature of 2,000° C. was required to explode firedamp, and gave the explosion temperatures of dynamite, nitro-glycerine, and guncotton, as 2,940°, 3,170° and 2,636° respectively. Similar mixtures are 20 per cent. of dynamite, etc., to 80 per cent. of nitrate of ammonium. Estimated temperature of explosion 1,130° C. (Mallard and Le Chatelier). Also Kubin and Sieuth's mixture of dynamite, with 20 to 50 per cent. of ammonium chloride or sulphate, or both, (Spec. No. 3759, 10. 3. 88) and for a similar purpose, Kuhnt and Diessler use 60 per cent. of carbonate of ammonia. (Spec. No. 5949, 21. 4. 88).

For use with tonite cartridges, Trench recommends an envelope of sal-ammoniac, salt, alum, and sawdust, saturated with water. The envelope is a paper case completely surrounding the cartridge, and containing the mixture as above. Settle's water cartridge, Heath and Frost's gelatinous cartridge, and those of other inventors, are mechanical means directed to the same end.

WILLARD, *see* HERCULES.

ADDENDUM.

It may be useful for the benefit of those who are more accustomed to the use of Service explosives than to those of the dynamite class, to insert here the substance of the instructions issued by Nobel's Explosives Co. (Ld.) * for the use of their explosives; a copy of them is issued with every 5 lb. packet.

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* The Company have kindly consented to the reproduction of these instructions here; *mutatis mutandis* they also apply to electrical firing with service or other detonators. The foot-notes are mine.

Instructions for using Dynamite, Blasting Gelatine, and Gelatine Dynamite.

Unlike gunpowder, dynamite, blasting gelatine, and gelatine dynamite, require a special mode of firing, which consists of a very strong percussion cap, called a "detonator," attached to a Bickford* fuze. The fuze sets fire to the fulminate, which then explodes the cartridge.

A charge is made as follows :—

1*st Operation.*—A Bickford fuze is cut clean, and inserted into a detonator till it reaches the fulminate. The upper part of the cap is then squeezed with a pair of nippers (as shown in *Fig.* 1.) The squeezing should not be neglected, as it not only secures the position of the fuze, but also serves to develop the power of the fulminate.

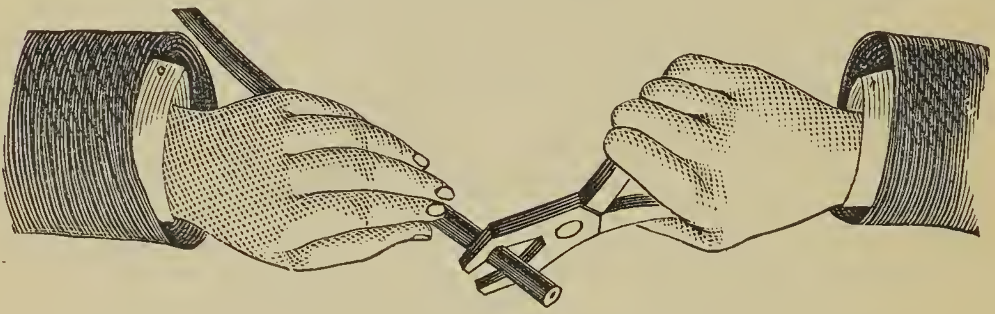

Fig. 1.

N.B.—For use under water, great care should be taken to have the upper end of the detonator made water-tight (with grease, tar, or otherwise) where it joins the fuze, to prevent the fulminate from getting damp.

2*nd Operation.*—A cartridge is opened at one end, and the detonator, with the fuze already attached to it, is pushed in so as to leave about one-third of the copper tube exposed outside the

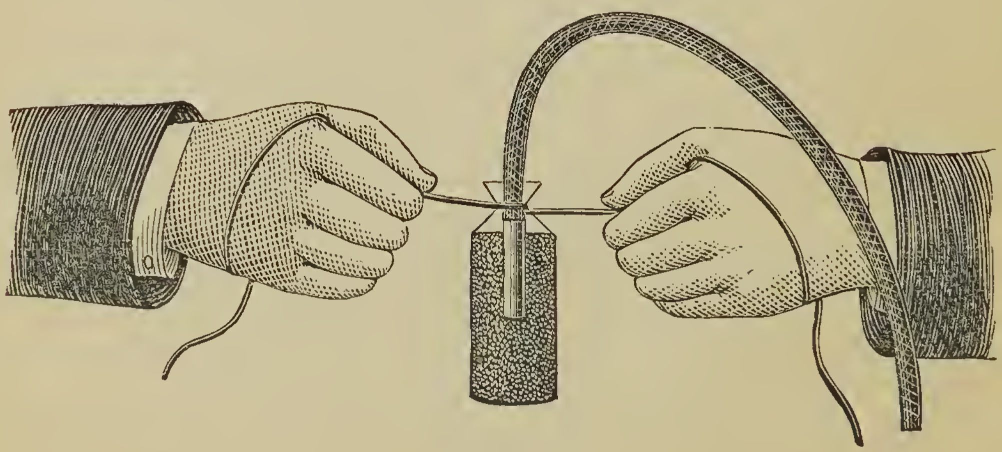

Fig. 2.

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* *i.e.* safety fuze or instantaneous fuze as the case may be.

cartridge. The detonator is then securely tied in that position. If the detonator is pushed too far into the cartridge, the fuze may set fire to the latter before the spark can explode the detonator, and unpleasant* fumes may be the consequence.

3rd Operation.—One or more cartridges (as the height of charge may require) are inserted into the borehole, and each squeezed separately with a wooden rammer (as shown in *Fig.* 3), so as to completely fill the borehole—never use iron in squeezing home cartridges.

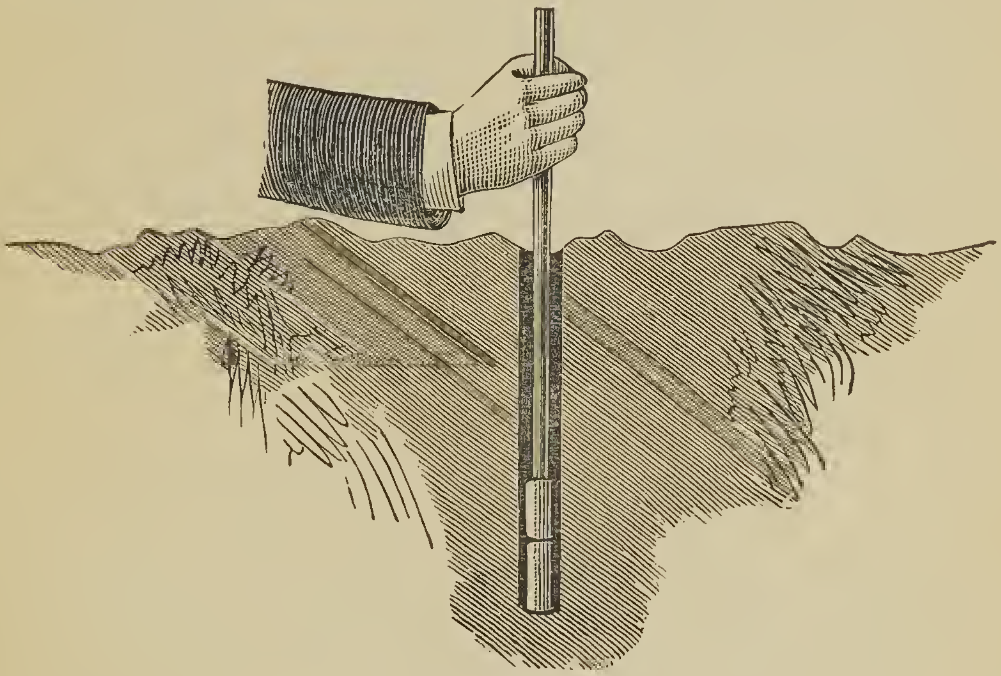

Fig. 3.

4th Operation.—Over the charge as shown in 3rd operation, the cartridge, with detonator and fuze affixed, is inserted, but not squeezed, and loose sand or water is poured in as tamping (as shown in *Fig.* 4). The charge is then ready for firing.

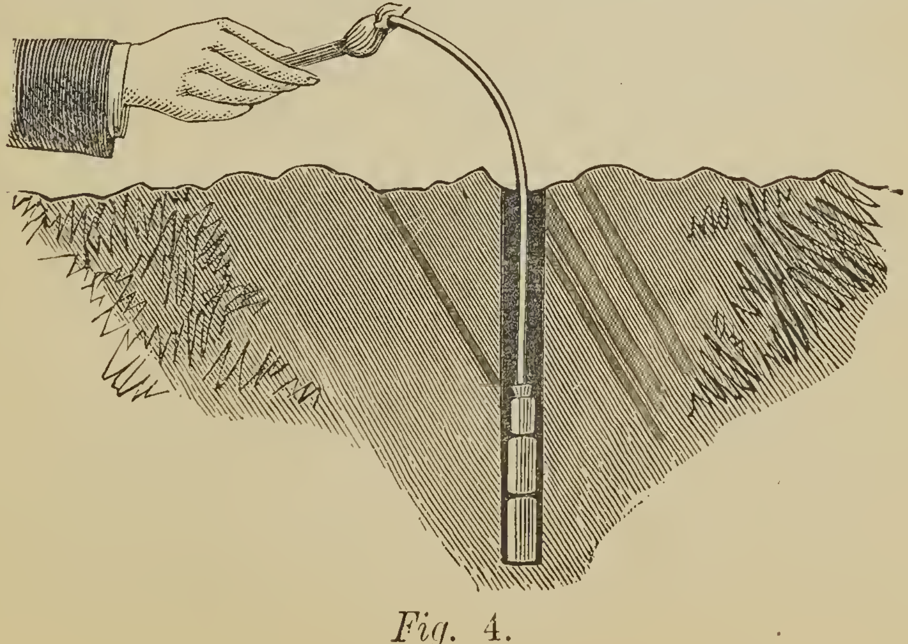

Fig. 4.

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* Not to say dangerous.

Treatment of Dynamite, Blasting Gelatine, and Gelatine Dynamite in Cold Weather.

In cold weather these explosives become hard or frozen, and lose their plastic or soft condition, but thaw and resume it when warmed.

Accidents have occurred through warming cartridges on or before stoves and fire-places; this is highly dangerous, for dynamite, when slowly heated to 420[*] degrees Fahrenheit, is liable to explode with great violence.

Frozen cartridges are easily and safely thawed, and made to resume their pasty condition by putting them in an empty water-tight tin can,[†] which should then be placed in a vessel of hot water, till the cartridges have resumed their normal condition.

N.B.—Special portable warm-water heating pans may be had from the Company or their agents, wherein the cartridges are kept warm, and in a soft, plastic state, for several hours in the coldest weather.

NOTE.—In tropical countries, open boxes of dynamite, blasting gelatine and gelatine dynamite should never be exposed to the direct rays of a tropical sun.

CLASS V.—GUNCOTTON AND OTHER NITRO-COMPOUNDS.

We now arrive at a class of explosives of which guncotton is the most important. If the alphabetical list be consulted, it will be seen that almost every organic substance rich in carbon and hydrogen is susceptible of being converted into a nitro-compound, but as yet only nitro-cellulose and, more recently, some nitro-forms of benzole and napthalene have attained any eminence in the ranks of explosives.

To Braconnot, in 1832, is attributed the discovery of the conversion of starch, woody fibre and similar substances, into highly combustible bodies by the action of concentrated nitric acid. The bodies so converted he called, generically, xyloidine. Pelouze six years afterwards pursued the subject and extended his researches to

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[*] This is rather high, probably 360° F. would be nearer the mark, but in any case the substance of the paragraph is perfectly correct. Moreover, nitro-glycerine compounds begin to decompose at temperatures much lower than this if long subjected to them, and hot cartridges are extremely sensitive to the least shock. Eissler says, p. 62, "At 350° the fall upon it of a dime will explode it."

[†] Special attention should be paid to this, and under no circumstances should the vessel containing the water be placed on or very near a fire. The water should be heated in a separate vessel or boiler and poured into the outer can. The temperature of the water when in this should not be higher than can be borne by the naked wrist, viz., about 130° F. The proper apparatus is a "warming-pan" as mentioned in the next paragraph, which is on the principle of a glue pot, and cannot be placed on or very near a fire without destroying it

cotton, paper, and vegetable substances generally. To him suceeded Dumas, who, with nitro-paper, which he termed nitramidine, proposed to make cartridges.

No practical result, however, came of these preliminary researches till Schönbein, in 1845, hit on the proper mode of manufacturing true guncotton by treating cotton with a mixture of strong nitric and sulphuric acids.

Nearly every country in Europe took up the matter with a view of utilising the new explosive for war purposes, and in Austria, under the auspices of von Lenk, the matter was closely investigated and the manufacture approved. The Austrians, indeed, in 1862, armed thirty batteries with guncotton cartridges in which the explosive was braided or twisted into yarns and ropes to diminish its rapid rate of burning. There, however, as in England and elsewhere, guncotton fell into disrepute from its unstable character, which resulted in many disasters.

Von Lenk had, it is true, introduced many improvements into the manufacture as distinguished from the crude methods hitherto pursued, but his project was not by any means perfect, and it was reserved for Abel to introduce his system of pulping, compressing, and thoroughly purifying guncotton, which has brought that explosive so much to the front, especially for military purposes.

The application of the principle of detonation to guncotton, and the discovery by the late E. O. Brown that perfectly wet and uninflammable (compressed) guncotton could be readily detonated by the detonation of a priming charge of the dry material in contact with it, raised it to the highest rank as a military explosive. As a mining agent it is to a considerable extent superseded by the plastic nitro-glycerine explosives, which are more easily inserted into an irregular bore-hole than the rigid guncotton.

In these pages I do not propose to enlarge on the manufacture and properties of guncotton, as they are fully given in the official text-books, but a few brief remarks may not be out of place.

Guncotton, or more generally nitro-cellulose, like nitro-glycerine, was formerly esteemed to be a nitro-substitution compound, but they are now both recognised as nitric ethers, and the equation for the formation of guncotton is thus given, cellulose being taken as a triatomic alcohol, ($C_6H_7O_2.3HO$).

$$C_6H_7O_2.3HO + 3HNO_3 = C_6H_7O_2.3NO_3$$

This equation is precisely analogous to that given for the formation of nitro-glycerine.

The acid mixture employed in the manufacture of guncotton at Waltham Abbey consists of three parts by weight of sulphuric acid (S.G. 1·84) to one part of nitric acid (S.G. 1·52). The use of weaker acids results in the production of lower nitro-compounds of the nature of collodion or soluble guncotton, which are so called as being soluble in alcohol and ether, which is not the case with the strongest form of nitro-cellulose.

The process of manufacturing compressed guncotton at Waltham Abbey consists of nitrating * the previously cleaned and dried cotton, eliminating all the free acid, and pulping and compressing the guncotton into the required forms.†

To produce a stable product the greatest care is required in the selection of materials, and above all in the total elimination of free acid. It was want of attention to these points, or imperfect methods of obtaining these ends, that caused guncotton to fall into disrepute for so long.

Theoretically 100 parts by weight of cellulose should produce 218·4 parts of guncotton, but practically, as in the analogous case of nitro-glycerine, the yield is a good deal less than this.

Broadly speaking, guncotton and nitro-glycerine compounds have much in common as respects their behaviour when burnt, exploded, or detonated, or when exposed to shocks or blows. There is, however, an important difference between guncutton and such of the nitro-glycerine compounds as can be kept like guncotton in water. Wet guncotton absorbs water throughout its mass, and when thus saturated is not only absolutely uninflammable, but requires a very abnormal amount of fulminate to detonate it, though it is easily detonated, as previously stated, by the initial detonation of some of the dry material in contact with it. The case is different with (say) blasting gelatine, into which the water does not penetrate but only wets its surface. When taken out of the water it is readily inflammable or susceptible of detonation in the ordinary way. For mining purposes guncotton, or the nitrated forms of it usually employed in blasting, has the advantage of not freezing, nor can any liquid explosive exude from it. On the other hand its rigid character, as pointed out above, is not so suitable for loading the average more or less irregular bore-hole as a plastic material like dynamite and its congeners. But for many warlike purposes this very rigidity, which enables it when compressed or sawn into any required form to retain such form permanently, is very valuable.

The products of perfectly detonated guncotton may be fairly expressed by the following equation :—

$$2\,(C_6H_7O_2.3\,NO_3) = 9\,CO + 3\,CO_2 + 7\,H_2O + N_6$$

It appears then that guncotton does not contain sufficient oxygen to completely burn up its carbon, and hence in the varieties used in

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* This word is commonly somewhat loosely used. To "nitrate" cellulose or glycerine means to convert it into nitro-cellulose nitro-glycerine by the action of nitric acid, but "nitrated guncotton" means guncotton to which nitrates have been added. No real confusion need arise when the context is noted in each case.

† Full particulars of the manufacture will be found in the official text-book.

mining, some nitrate is always added to supply this defect, and this addition moreover tends to prevent the evolution of the actively poisonous CO.*

Here appears an additional reason why the blasting gelatines considered simply as a mixture of nitro-glycerine and nitro-cotton form such a happy mixture. One has too little oxygen,† the other too much, and thus the two act as help-meets to each other.

The nitro-compounds other than guncotton mentioned in this section are not at present very prominent in the ranks of explosives now in use, with the exception of the nitro-benzoles and kindred nitro-compounds, *e.g.*, nitro-naphthalene, which are now being used as important constituents of such explosives as kinetite, securite, roburite, etc.

Benzole (C_6H_6) is obtained from coal tar as a very inflammable, brilliant, colourless liquid. The action of nitric acid on this liquid produces nitro-benzole ($C_6H_5.NO_2$) a heavy, yellow, oily liquid with a characteristic odour of bitter almonds. It is very largely used for the manufacture of aniline ($C_6H_5.NH_2$), and hence for the numerous aniline dyes. By the further action of nitric acid on the mono-nitro-benzole another atom of hydrogen is displaced, and di-nitro-benzole ($C_6H_4.2NO_2$) is obtained, which appears as "long, shining needles or laminæ, which melt below 100° C. and solidify into a radiated mass."‡

It is to be noted that the nitro-benzoles are true nitro-substitution compounds, as nitro-glycerine and guncotton were formerly supposed to be, not nitric ethers, as later research has shown the last-named substances to be.§ The prefix of "meta" to di-nitro-benzole refers to chemical theories which need not be cited here, suffice it to say that three series of nitro-benzoles can be formed, the "ortho," "para," and "meta" series, which are identical in composition, but exhibit physical and other characteristics of difference between them.

As nitro and di-nitro-benzole are active poisons great care should be taken not to handle explosives containing them and unprotected by a cartridge case or other envelope, more than is absolutely necessary. On no account after such handling should food be touched with unwashed hands. Persons who are obliged to deal much with the bare explosive should drink milk.

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* I may here remark that it is not uncommon to hear that such and such an explosive gives off "no noxious fumes." No explosive exists to my knowledge of which this can be truly said. If *perfect* explosion or detonation be achieved, then we have at least a considerable amount of CO_2 which is not a harmless gas, but in actual work-a-day practice such perfection is exceptional, and we have CO and nitrous fumes evolved. Men have been killed by poisonous fumes from an explosive which was stated to be absolutely harmless in this way.

† The soluble nitro-cottons used in this explosive contain less oxygen in proportion than guncotton.

‡ Watt's *Dict. of Chem.*, I., 544.

§ The distinction depends on chemical questions, which need not be discussed here, though it may be stated that if guncotton, for instance, were really a nitro-substitution compound it might be expected to furnish an organic base under the influence of reducing agents, just as nitro-benzole under such influence furnishes the base aniline.

ABEL, in 1865, patented his process of pulping and compressing guncotton (Spec. No. 1,102, 20. 4. 65.), and in 1867 he patented guncotton in conjunction with a large portion of an oxydising body, such as chlorate or nitrate of potash, or nitrate of soda, or mixtures thereof, with the addition of a small proportion of alkali or of an alkaline carbonate such as carbonate of soda. He recommended a proportion of 70 to 40 per cent. of guncotton, with 30 to 60 per cent. of the oxidising substances, and added about one per cent. of the alkali. The same patent comprises the admixture of guncotton with nitro-glycerine, *see* GLYOXILINE. (Spec. No. 3,652, 24. 12. 67.) *See* also introduction to this section.

AMMONIA-NITRATE POWDER consists of :—

Ammonium nitrate	80 parts
Potassium chlorate	5 ,,
Nitro-glucose	10 ,,
Coal tar	5 ,,

(M. No. XIII., p. 245).

AUDEMARS took the bark of mulberry or other trees of the *morus* genus, boiled it first with carbonate of soda and then with a solution of soap, washed it in hot water acidulated with nitric acid, and dried it by pressure. The fibre thus treated was soaked in a mixture of ammonia and alcohol and bleached with chloride of lime. It was then to be hackled, carded, and spun like cotton, treated with nitric acid and "converted into an explosive compound resembling guncotton." (Spec. No. 283, 6. 2. 55).

BANTOCK proposed to prepare nitro-cellulose by treating with the usual acids and adding a neutral salt. He suggests a mixture of 34 lbs. of nitric acid (S.G. 1·5); 65 lbs. of sulphuric acid (S.G. 1·84) and 1 lb. of anhydrous sulphate of potassium. To 100 lbs. of this mixture 8 lbs of dry cellulose is to be added. To the nitro-cellulose thus prepared 25 lbs. of saltpetre and 15 lbs. of chlorate of potash are to be added. As will be seen this (with the exception of the addition of the neutral salt) is simply Abel's nitrated guncotton. (Spec. No. 4,806, 12. 12. 76).

BARNWELL proposed to use pyroxiline in solution as a varnish, or in combination with plastic substances for moulding. In a

powdered form it was proposed to use it in gunpowder as a substitute for charcoal. (Spec. 2,249, 15. 9. 60).

Bellite, introduced by Mr. C. Lamm, at Stockholm, is much like Roburite or Securite, consisting of a mixture of nitrate of ammonium with a di or tri-nitro-benzole. It has been recently licensed in this country.

Bjorkmann, E. A., treated sugar or other saccharine matters with nitric and sulphuric acids and added 25 to 50 per cent. of it, which he termed "Nitroline," to nitrate and chlorate of potash, cellulose, charcoal, other vegetable substances, coal, tannin, or "compounds of such substances." The explosive could be made as a powder or of the consistency of wax, and was called Vigorite. (Spec. 2,459, 8. 7. 75).

Bjorkmann, C. G., proposed an explosive consisting of the following :—

Nitrate of potash	20	parts
Chlorate ,, ...	20	,,
"Cellulosa"	10	,,
Peameal	10	,,
Sawdust	10	,,
"Nitroline"	30	,,

The "cellulosa" is made by the action of 20 parts nitric and 40 parts sulphuric acid on 12 parts peameal.

The "nitroline" is made by the action of 80 parts nitric and 170 parts of sulphuric acid on 15 parts raw stearic oil and 15 parts syrup.

The compound is fired by a priming charge of gunpowder. (T., p. 104).

It is obvious that these two explosives last described are modifications of the same. The first description is from the English, the second from the American patent.

The same inventor proposed also to mix glycerine with one-third of its weight of a carbo-hydrate, such as sucrose or glucose, and to heat the mixture with 2½ times its weight of strong nitric acid. This "blasting oil," he claims, is not nitro-glycerine.*

He proposes an explosive composed of :—

"Blasting oil," as above	60	parts
Binoxide of manganese	18	,,
Prussiate of potash	10	,,
Sulphide of antimony...	2	,,
Pine sawdust or coal dust...	10	,,

The above is stated not to freeze, to be insensible to shock, and not to be poisonous. (Spec. No. 2,483, 19. 6. 80).

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* But see Glukodine, p. 52.

CARBONIT made by Buchel and Schmidt, of Schlebusch, is claimed to be a safe explosive for use in fiery mines. Two varieties of it were submitted for licensing in this country in 1888, intended for use in coal and stone respectively. That for coal was a brown, friable mass; that for stone a black, moist, plastic one. They contained much the same ingredients, but in different proportions. The "stone" variety was rejected for exudation, the "coal" one was accepted, and is defined as consisting of not more than 25 parts of thoroughly purified nitro-glycerine (with or without the addition of not more than half a part of sulphuretted benzole) uniformly mixed with 75 parts by weight of a pulverised preparation consisting of wood meal not less than 40 parts, nitrates of potassium and barium (or either of them) not more than 34 parts, and carbonate of sodium not more than half a part, such preparation to be sufficiently absorbent when mixed in the above proportions to prevent exudation of nitro-glycerine. (See also Spec. No. 14,623, 11. 11. 86).

CELLULOSA, *see* BJORKMANN, C. G.

CLARK proposed a wood gunpowder manufactured by treating grains of wood or wood pulp impregnated with alum or tannin with the usual acids. After nitration the grains are to be steeped in alum solution or boiled in potash solution, and then impregnated with a solution of nitrate of potash or soda. They may finally be coated with collodion. (Spec. No. 1,210, 11. 4. 68).

He subsequently proposed to dilute the acid adhering to the pyroxiline after nitration with water "sufficient to prevent oxidation of the pyroxiline" and to add to the moist compound "carbonate or bi-carbonate or chlorate (!) or chromate of potash." A process admirably adapted to secure immediate explosion, or at least firing of the acid pyroxiline. He also proposed to saturate vegetable fibre with glycerine and nitrate the whole to form "glycero-pyroxyline." (Spec. No. 3,408, 10. 11. 68).

COOPPAL'S POWDER is practically much the same as Schultze gunpowder, and consists of nitro-lignin carefully purified, with or without an admixture of a nitrate or nitrates (other than nitrate of lead) and starch. It is an "authorised" explosive.

COTTON POWDER, *see* TONITE.

DAVEY treated "as much starch or dextrine, or gum, or flour, or sugar, as will be dissolved" by boiling with a mixture of one part of nitric to three parts sulphuric acid. Hence he obtained "an acidulated preparation" which he proposed to

mix in the proportion of 4 to 6 per cent. with the ingredients of ordinary gunpowder, the sulphur being "lessened or replaced" by the hydro-carbon. It is to be hoped that this was never tried anywhere on a manufacturing scale, as the conditions are excellently calculated to produce accidents. (Spec. No. 2,072, 21. 7. 62).

He also proposed in another patent to treat guncotton with a solution of chromates, sesqui-chromates, or bi-chromates, with or without the addition of nitrate of potash (or similar salt) and gum or hydro-carbon.

This chromated guncotton he proposed to waterproof and use it in a mining fuze in lieu of ordinary gunpowder. (Spec. No. 2,832, 25. 7. 77).

Di-Flamyr, signifying in Welsh flameless, is a recently licensed form of nitrated guncotton.

Dittmar, *see* Titan and Xyloglodine.

Dulitz makes a jelly of guncotton in nitro-benzene, and adds this to four times its weight of chlorate of potash. Up to 10 per cent. of another oxidizing agent may be substituted for an equivalent amount of the chlorate. (Spec. No. 12,838, 17. 8. 86). See also Kinetite.

E. C. Powders consist of Rifle Guncotton. They are divided into two divisions: *Sporting Powder*, coloured with aurine (free from mineral acid) dissolved in ether, alcohol, and benzoline, and *Rifle Powder*, coloured with picric acid (free from mineral acid) dissolved in the same solvent. They are small round granules coloured respectively orange and yellow, and consist essentially of diluted nitrated guncotton.

Two samples gave :—

Nitro-cellulose soluble	27·95	21·79
,, ,, insoluble...	28·35	25·58
Cellulose (unconverted)	3·15	4·17
Nitrates of potassium and barium	37·80	38·32
Matters soluble in benzole	0·60	1·95
,, ,, ,, alcohol	2·15	6·32
	—	1·87 (moisture).

See also Johnson's Powders.

Emilite (P. M. E. Audouin). The portion of coal tar boiling between 185° and 200° C. is nitrated, after removing resinous matters. (Spec. No. 5,899, 22. 4. 87).

Favier's Explosive consists of a compressed hollow cylinder composed of 91·5 parts of nitrate of ammonium and 8·5 parts of mono-nitro-naphthalene, filled inside with loose powder of the same composition. The cartridges are enclosed in waterproof wrappers. This explosive has been licensed in this country under the name of "Miners' Safety Explosive." In the specification the idea is started of filling the central cavity with a stronger explosive, *e.g.*, dynamite, guncotton, etc. (Spec. No. 2,139, 16. 2. 85).

Felhoen, *see* Nitro-naphthaline.

Gilles, *see* Nitro-Molasses.

Glycero-pyroxiline, *see* Clark.

Guncotton, *see* introduction to this section.

Huetter's blasting compound consists of the same ingredients as Tonite.

Johnson's Powders. In these powders di-nitro-cellulose or lower forms of nitro-cellulose are employed, impregnated with barium or potassium nitrates and incorporated with charcoal or other carbonaceous material. Two examples given in the specification consist of the following:—

	For Military Arms.	For Sporting Arms.
Nitro-cellulose	50 parts	50 parts
Potassium nitrate ...	40 ,, ...	22 ,,
Barium nitrate	— ,, ...	25 ,,
Torrefied starch or lamp black ...	10 ,, ...	3 ,,

The powders are formed into grains, or blocks, and impregnated with a solution of camphor and phenol, or camphor alone, in a suitable volatile solvent, in the proportion of one part of camphor (or camphor and phenol) in five parts of solvent to ten parts of the powder. The solvent is driven off at a gentle heat, and the camphor subsequently driven off at a temperature not exceeding 100° C.

It is claimed that by this method powders can be produced of any required degree of hardness and density, thereby regulating the energy of action of the explosive; and it is stated that "these results are obtained not by the presence of "camphor in large or small quantities in the finished ex-"plosive, but by a remarkable gelatinizing and perhaps some "other actions exerted by the camphor upon the nitro-cellu-"lose when these are heated together at varying temperatures "up to 100° C., whereby the hardness and density of the "explosive may be regulated at will by the proportion of "camphor used." He expressly bars the use of ordinary guncotton on account of the elements of uncertainty and danger introduced by it. (Spec. No. 8,951, 24. 7. 85).

These powders have recently been licensed for manufacture by the E. C. Company, under the name of "E. C. Powder Company's [sporting or rifle] powder J. B. Patent."

KEIL'S EXPLOSIVE consists of nitro-glucose (dextro-glucose made from starch) compounded with nitrate and chlorate of potash and prepared vegetable fibre. (T., p. 107).

KINETITE (T. Petry and O. Fallenstein) consists of nitro-benzole thickened or gelatinized by the addition of some collodion cotton incorporated with finely ground chlorate of potash and precipitated sulphide of antimony. It requires a very high temperature, comparatively, to ignite it, and cannot under ordinary circumstances when unconfined be exploded by the application of heat. It is but little affected by immersion in water unless it be prolonged, when the chlorate dissolves out, leaving a practically inexplosive residue.* But it is unfortunately extremely sensitive to combined friction and percussion, and is readily ignited by a glancing blow of wood upon wood. It is also deficient in chemical stability, and has been known to ignite spontaneously both in the laboratory and in a magazine.

It is an orange coloured, plastic mass, with the characteristic strong smell of nitro-benzole.

A variety of it contains nitrate of potash in lieu of sulphide of antimony, but this, though slightly less sensitive than that described above, is still dangerously so to combined friction and percussion.

The proportions found in a sample of the first variety were :—

Nitro-benzole	19·4
Chlorate of potash	76·9
Sulphide of antimony Nitro-cotton	3·7†

(Spec. No. 10,936, 6. 7. 84).

LANFREY'S POWDER consists of straw treated with the usual acids to produce a nitro-cellulose, which is afterwards impregnated with a solution containing saltpetre, hardwood, charcoal and dextrine. It was proposed also to impregnate this nitro-straw with nitro-glycerine to form a "straw dynamite." The silica present in the straw is said to give stability, though on what grounds it is not quite easy to see. (Spec. No. 3,119, 7. 8. 78).

LANNOY POWDER. This is a white powder composed of :—

Nitrate of soda	65	parts
Sulphur	13	,,
Wood, sawdust, or bran nitrated	22	,,

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* If, however, it be exposed to moist and dry air alternately, the chlorate crystallises out on to the surface and renders the explosive very sensitive.

† See also DULITZ. A full account of this explosive is given in a lecture reported in the *Journal of the Society of Chemical Industry* for January, 1887.

It is stated to ignite with difficulty and to burn slowly in air. It gives out strong sickening fumes. (D., p. 669).

LIGHTNING PAPER is rather a toy fire-work than an explosive. It consists of thin sheets of paper treated with the usual acids, and is a mixture of tri-nitro-cellulose and lower forms. It is impregnated with various metallic salts to give a coloured flame.

LIVERPOOL COTTON POWDER, *see* POTENTITE.

MACKIE, in his patent taken out in conjunction with FAURE for a process of manufacturing guncotton, also proposed a blasting powder consisting of nitrated guncotton (or similar substance) mixed with resin, shellac, ozokerit, collodion, glycerine, charcoal, or soot. An an instance a mixture is given of five to ten parts guncotton with two parts of resin and one of nitre. If glycerine or ozokerit be used a plastic compound is obtained. (Spec. No. 1,830, 20. 5. 73).

In conjunction with FAURE and TRENCH he subsequently patented the admixture of nitrate of baryta with guncotton (*see* TONITE). (Spec. No. 3,612, 20. 10. 74).

Afterwards the same persons patented the use of esparto grass, hemp, flax, straw, hay, agave and yucca fibre, and other vegetable substances or substitutes for cotton. (Spec. No. 2,742, 4. 7. 76).

MINER'S SAFETY EXPLOSIVE, *see* FAVIER'S EXPLOSIVE.

MUSCHAMP patented a pulping and bleaching process for rags or other vegetable fibres, in conjunction with REEVES in 1866, the chemical agent used being chloride of lime. (Spec. No. 3,293, 15. 12. 66).

In 1871 he patented a wood pulp process, and proposed to utilise the acids used in dipping the first batch of cellulose to make weaker nitro-compounds, by dipping second and third batches in them. To retain rapidity of explosion he steeped his nitro-compound in a solution of sulphate of zinc or lead, or in a solution of starch. The charges when made up were waterproofed with collodion or other substance. (Spec. No. 1,326, 16. 5. 71).

NITRAMIDINE, a name given by Dumas to pyroxiline prepared from paper or cardboard.

NITRATED GUNCOTTON is a general term applied to all admixtures of guncotton with nitrates. In this country nitrate of lead is forbidden to be used on account of the deleterious fumes produced by it on explosion.

NITRESINE is a combination of nitric acid and resin proposed as an absorbent for liquid explosives. (T., p. 107).

NITRO-BENZOLE, *see* introduction to this section.

NITRO-COAL is the result of the action of nitric acid on powdered coal. On account of the violent action of strong acids on the coal the nitration in the experiments made had to be carried on in stages. First nitric acid of S.G. 1·40 to 1·48 was used, and after some manipulation a nitro-product was thrown down as a brown powder. This was washed and dried and then treated with the strongest nitrating agents. The results obtained were not encouraging from a commercial point of view, on account of the large consumption of acid, especially when wood charcoal and coke were experimented upon. (M. No. II., p. 453).

NITRO-COLLE consists of isinglass or gelatine soaked in cold water. It is then melted at a gentle heat and sufficient nitric acid is added to prevent its solidifying when cold. It is then treated with the usual acids. Another method is to place strong glue in cold water until it has absorbed the maximum amount of the latter. The mixture is solidified by the addition of nitric acid, nitrated in the usual way, and well washed.

NITRO-COTTON, a generic term applied to pyroxiline made from cotton.

NITRO-GLUCOSE, *see* KEIL.

NITRO-LIGNIN, a generic term applied to pyroxiline made from woody fibre, in contradistinction to that made from cotton (nitro-cotton).

NITROLINE, *see* BJORKMANN.

NITRO-MANNITE ($C_6H_8(NO_3)_6$) is prepared by treating mannite ($C_6H_{14}O_6$) with the usual acids. Mannite or sugar of manna exists in many vegetables, but is usually prepared from manna, a saccharine juice obtained from two species of ash.

Nitro-mannite forms white needle-shaped crystals, insoluble in water but soluble in ether or alcohol. Rapidly heated it ignites in about 374° F., and explodes at about 590° F. It is more susceptible to friction and percussion than nitro-glycerine. Sulphide of ammonium re-converts it into mannite. Unless pure it is liable to spontaneous decomposition.

It may be considered as the nitric ether of the hexatomic alcohol mannite.

NITRO-MOLASSES is prepared by nitrating 380 parts molasses with 1,000 parts fuming nitric acid and 2,000 parts concentrated sulphuric acid. The product when washed is a grey yellow or whitish precipitate. By a special treatment a liquid nitro-product is obtained in lieu of a solid one. (Spec. No. 1,883, 13. 4. 83).

NITRO-NAPHTHALENE is formed by the action of nitric acid on naphthalene ($C_{10}H_8$); mono, di, and tri-nitro-naphthalene are known.

Felhoen patented an explosive consisting of ten parts of nitro-naphthalene with the crude ingredients of gunpowder, thus :—

Nitro-naphthalene	10	parts
Saltpetre	75	,,
Charcoal	12½	,,
Sulphur	12½	,,

He stated that he obtained a mono-nitro-naphthalene ($C_{10}H_7 . NO_2$) containing a small proportion of di-nitro-naphthalene ($C_{10}H_6 . 2\,NO_2$) by digesting one part of naphthalene, with or without heat, in four parts of nitric acid (S.G. 1·40) for five days. (Spec. No. 2,266, 9. 6. 79).

NITRO-PEAT is the result of the action of the usual acids on peat. The humus of the peat was converted into a dark brown sticky liquid like that obtained by nitrating the heaviest tar oils, while the finely-divided vegetable fibres were converted also into a nitro-compound. Peat of recent formation gave a violent action with the strong acid, and a preferable description was found in a firm solid peat of somewhat ancient formation. Like nitro-tars and similar products, nitro-peat has about the same specific gravity as water. It has a powerful aromatic odour, especially when burnt. It burns in the open air with a smoky flame. (M. No. II., p. 453).

NITRO-SACCHAROSE is produced by nitrating sugar. It is a white, sandy, explosive substance, soluble in alcohol and ether. That made from cane sugar does not crystallize from solution, while that made from milk sugar does. It has been used in percussion caps, being even stronger and quicker than nitro-glycerine, but owing to difficulties inherent in its manufacture, its great sensitiveness, and its hygroscopic qualities, combined with its proneness to decomposition, it is not used, by itself at least, as an explosive for blasting. *See* also GLUKODINE in *Nitro-glycerine Compounds.* (D., p. 671, and M. No. II., p. 446).

NITRO-STARCH, called also XYLOÏDINE and PYROXYLAM, is a white powder produced by the action of the usual acids on starch.

The starch cannot be put directly into the mixture of acids, because it would form clots, which would not be entirely acted upon. Uchatius's process is to dissolve one part of potato starch in eight parts of fuming nitric acid, keeping it cool. The resulting sirupy solution is poured in a stream into 16 parts of concentrated sulphuric acid and kept stirred. The mixture is left to stand 12 hours, then washed, treated with a boiling solution of carbonate of soda, and dried.

This powder is very hygroscopic, insoluble in water and alcohol, but soluble in ether. It readily decomposes spontaneously. When dry it is very explosive and takes fire at about 350° F. It does not appear to have come into practical use. (D., p. 670).

NITRO-TAR has been made from crude tar oils by direct nitration with strong nitric acid. The nitro-substances were washed, dried, and mixed with alkaline nitrates, chlorate of potash, or similar substances. The ordinary coal tar was also tried, but it became evident that its treatment with strong nitric acids was dangerous, and that the process on a large scale was likely to fail. But satisfactory nitro-compounds were obtained by the use of a weaker acid (S.G. 1·53 to 1·45) which when mixed with nitrates, etc., gave a good explosive, as did a solution of them in concentrated nitric acid.

Somewhat similar results were obtained from nitro-compounds formed from pitch and liquid hydro-carbons, but they were found to require much more addition of oxygenated bodies than the nitro-compounds obtained from tar or tar oils. (M. No. II., p. 451, *et seq.*). See also SCHULTZE and EMILITE.

NITRO-TOLUOLE. Mowbray patented a mixture of three parts nitro-toluole to seven parts of nitro-glycerine, but states that he manufactures his nitro-toluole "similarly to nitro-glycerine." Some confusion seems here to exist between the two hydro-carbons, benzole (C_6H_6) and toluole (C_7H_8). He also gives a mixture of the two ingredients in the proportion of 1 to 3. This he states to be a very safe explosive, but being a liquid not easily congealed, if a leak should occur in the containing vessel, the nitro-toluole (? nitro-benzole) is liable to evaporate, leaving the nitro-glycerine alone. (T., 101, and Mowbray, p. 38).

PAPIER FULMINANT, *see* PYRO-PAPIER.

PATENT GUNPOWDER. This was a wood gunpowder (nitro-lignin) formerly manufactured at Glyn Ceiriog, in Wales. The loss of the *Great Queensland* in 1876 was held by the Wreck Commissioners Court to be probably due to the presence of this powder on board, which by reason of its impure condition when shipped ignited spontaneously.

Petrofracteur consists of :—

Nitro-benzene	10 parts
Chlorate of potash	67 ,,
Nitrate	20 ,,
Sulphide of antimony	3 ,,

It generally resembles Kinetite, *q.v.*, but contains no nitro-cotton. It was favourably reported upon by an Austrian Military Committee. (*Journal of Soc. Chem., Ind.*, Vol. VI., p. 5).

Plera, a fancy name given to Rifle Guncotton.

Potentite is a nitrated guncotton identical with Tonite, except that saltpetre is usually used instead of nitrate of baryta.

Prentice proposed to regulate the speed of burning of guncotton by weaving or interlacing yarns of inert cotton with yarns of guncotton, or by pulping the two togother. He suggested a paper for sporting purposes made of 15 parts of unconverted to 85 parts of converted fibre. About 30 grains of such paper rolled into a cylinder was suggested as a proper charge for 1 oz. of shot. (Spec. No. 953, 3. 4. 66).

Punshon's Guncotton was prepared with a view of regulating its rapidity of explosion. The guncotton was soaked twelve hours in a solution of sugar, preferably refined or crystalised. He also added what he termed "a flux or an explosive, such "as white or ordinary gunpowder, or nitrate of soda or "potash, or ordinary guncotton, or a guncotton containing "from 5 to 20 per cent. of nitrate of potash or nitrate of "soda, combined with equal or double the same weight of "sugar." The object of this was to aid the development of the explosive force. The resulting mass was cut into suitable sizes. This explosive is simply nitrated guncotton mixed with sugar. (Spec. No. 2,867, 31. 10. 70).

Pyropapier or Papier Fulminant is made by immersing for two minutes unsized paper into equal parts of nitric and sulphuric acids. It is washed, treated with an ammoniacal solution, re-washed, and dried. It has been employed as a primer for the needle gun. (D. p. 667).

Pyroxylam, *see* Nitro-Starch.

Pyroxiline, or Pyroxyle or Pyroxylol, is a generic name for all the nitro-substances formed from various forms of cellulose. It includes, for instance, guncotton, gunpaper, wood gunpowder, etc.

Reeves (*see* also **Muschamp**) proposed to obtain a graduated series of explosives by immersing his material (cellulose in various forms) in a bath of one part of nitric to two parts by volume of sulphuric acid. The first lot was left in the bath 22 to 26 hours; the second lot 32 to 60 hours, about one-twentieth of the original amount of nitric acid being added; the third lot 2½ to 4 days, 15 to 25 per cent. of the original amount of nitric acid being added. He stated a fourth and fifth lot might be dipped in the bath either with or without the further addition of nitric acid.

The nitro-cottons thus obtained were to be mixed as required. (Spec. No. 989, 2. 4. 67).

Rifle Guncotton is guncotton mixed or not mixed with a nitrate, other than nitrate of lead, mixed with any one or more of the following substances, viz., pure beeswax, paraffin, shellac, gums or resins dissolved in ether, alcohol, and benzoline, such substances to be free from mineral acid. It is "authorized."

Robertson treated nitro-cellulose with a solution of chlorate of potash and coated the result with collodion. He proposed to use this in the form of a covering for a gunpowder cartridge. (Spec. No. 2,601, 18. 10. 61).

Roburite is an explosive due to Dr. C. Roth, and is now being manufactured on a commercial scale in this country. It has been for some time in use in Germany. It essentially consists of a mixture of nitrate of ammonium with chlorinated di-nitro-benzole, and thus much resembles **Bellite** and **Securite**. It is a brownish yellow powder, with the characteristic smell of nitro-benzole.

In the license it is defined as consisting of a mixture of:—

(*a*). Nitrate of ammonium with or without an admixture of nitrate of sodium and neutral sulphate of ammonium, or either of them, provided that the amount of nitrate of sodium so added shall in no case exceed 50 per cent. of the total amount of nitrates present; and

(*b*). Thoroughly purified chlorinated di-nitro-benzole, with or without the addition of thoroughly purified chloro-nitro-naphthalene and chloro-nitro-benzole, provided that such chlorinated di-nitro-benzole shall not contain more than 4 parts by weight of chlorine to every 100 parts by weight of chlorinated di-nitro-benzole, and that the proportions of chloro-nitro-naphthalene and chloro-nitro-benzole shall not amount to more than 2 per cent. and 5 per cent. respectively of the finished explosive.

This definition succeeded a much simpler one, in which the two main ingredients alone were designated.

The meta-di-nitro-benzole ($C_6H_4 . 2\,NO_2$) is obtained by the action of nitric acid on benzole (C_6H_6) or on nitro-benzole ($C_6H_5NO_2$), and the chloro-nitro form is represented by $C_6H_3Cl(NO_2)_2$. Roburite volatilises without explosion or ignition when slowly heated, and burns slowly in the open, at all events in small quantities. It requires a powerful detonator to develop its force.

ROLLASON, *see* BARNWELL.

ROMIT is a Swedish explosive, consisting of a mixture of nitrate of ammonia and napthalene (or nitro-napthalene) with chlorate and nitrate of potash. It was submitted for licensing in 1888, but rejected on account of its chemical instability, due to action between the nitrate and chlorate.

SAWDUST GUNPOWDER is a form of nitro-lignin, made, as its name indicates, from sawdust. It is an authorized explosive, but is seldom, if ever, manufactured.

SCHULTZE GUNPOWDER consists of nitro-lignin mixed or impregnated with a nitrate or nitrates (other than nitrate of lead) and with or without starch or collodion (such collodion to consist of nitro-lignin dissolved in ether and alcohol) or solid paraffin free from mineral acid. A sample gave the following proportions :—

Soluble nitro-lignin	24·83
Insoluble ,, ...	23·36
Lignin (unconverted)	13·14
Nitrates of potassium and barium ...	32·35
Paraffin	3·65
Matters soluble in alcohol...	0·11
Moisture	2·56

SCHULTZE BLASTING POWDER consists of the above, with the addition of charcoal.

Both the Schultze powders are authorised explosives.

Schultze has also proposed the following powders :—

	Sporting.	Rifle.	Blasting.
Nitro-tar (or similar nitro compound) ...	12	10	15
Pyroxiline	60 to 80	280 to 300	10
Barium nitrate	60 to 80	100 to 120	—
Potassium nitrate	8 to 10	40 to 50	75
Sulphur	—	10	10

(M. No. XV., p. 590).

SECURITE, like BELLITE and ROBURITE, consists of a mixture of meta-di-nitro-benzole with nitrate of ammonium. The proportions are about 26 parts of the former to 74 of the latter. It is a yellow powder with the odour of nitro-benzole. It was submitted for license in 1886, and was approved. Other

varieties contain tri-nitro-benzole or di or tri-nitro-napthalene. The following equations are given as representing the various compositions and their products of combustion, and claim to show that it is a perfectly safe explosive to use in the presence of fire-damp and coal-dust:—

$$C_6H_4 . 2\,NO_2 + 10\,(NH_4 . NO_3) = 6\,CO_2 + 22\,H_2O + N_{22}$$
$$2\,(C_6H_3 . 3\,NO_2) + 15\,(NH_4 . NO_3) = 12\,CO_2 + 33\,H_2O + N_{36}$$
$$C_{10}H_6 . 2\,NO_2 + 19\,(NH_4 . NO_3) = 10\,CO_2 + 41\,H_2O + N_{40}$$
$$2\,(C_{10}H_5 . 3\,NO_2) + 33\,(NH_4 . NO_3) = 20\,CO_2 + 71\,H_2O + N_{72}$$

(*Paper by S. B. Coxon, at North of Eng. Inst., Mining and Mech. Eng. 11. 2. 87.*)

A variety known as FLAMELESS SECURITE (F. Shöneweg) consists of a mixture of nitrate and oxalate of ammonia and di-nitro-benzole. It has been submitted for license and approved.

SILOTVAR (W. von Ruckterschell) is wood fibre treated with equal parts of nitric and sulphuric acids. It is therefore simply a weak nitro-cellulose. It looks like dry, flocculent sponge. It was submitted for licensing, but rejected as not standing heat test. (Spec. No. 4,349 of 1886).

SMOKELESS POWDER is defined in the same terms as SCHULTZE GUNPOWDER. But under the generic term of "Smokeless Powder" a large class is comprised, to which at present much attention is being devoted with the object of discovering a comparatively smokeless and noiseless powder for use in military arms. A considerable number of such powders are in the field, and experiments are being conducted with a view to ascertain those best suited for military requirements. Nearly, if not quite, all of them are composed of various grades of nitro-cellulose specially treated and mixed or combined with other substances. They are, in fact, modifications of the various forms of sporting nitro-compounds now so largely used. A variety, patented by Abel, consists of nitro-cotton and nitrate of ammonia, waterproofed by petroleum or camphoretted. (Spec. No. 14,803, 14. 9. 86). Others consist of nitro-cellulose treated with solvents, such as acetic ether. At present, however, details cannot expediently be published.

TITAN POWDER consists of vegetable fibre, pulped, compressed, granulated, and treated with the usual acids. Also vegetable fibre prepared with a solution of sugar, or mannite, or amyline,[*] or inuline,[†] and then treated with acids. This last gives obviously a mixture of various nitro-compounds. (T., p. 102).

TONITE or COTTON POWDER is a nitrated guncotton, the nitrate usually employed being that of barium. It is usually issued in the form of cartridges, coated with paraffin of a brown hue. The No. 2 variety is the same as the above, with the addition of charcoal, which gives the resulting compound a grey appearance. Both varieties are authorised explosives.

TONKIN proposed to mix together :—

Pulped guncotton	3 parts
Nitrate of potash or soda	56 ,,
Charcoal	26 ,,
Sulphur	15 ,,

In some cases the cotton was to be employed in an unconverted state. The compound was a sort of gunpowder, with 3 per cent. of guncotton. It was to be granulated.

TRENCH, *see* MACKIE.

TROTMAN proposed to mix guncotton or other nitro-cellulose, in the condition of pulp or powder, with silicate cotton.[‡] The object is to retard the explosion of guncotton by mixing with it an inert, non-hygroscopic material. The proportions recommended are 25 parts of silicate cotton to 75 parts of guncotton. (Spec. No. 2,536, 24. 6. 79).

UCHATIUS, *see* NITRO-STARCH.

VIGORITE, *see* BJORKMANN. For a nitro-glycerine compound of the same name, *see* nitro-glycerine section.

VOLNEY'S POWDER consists of nitro-naphthalene mixed with an oxidising agent. (T., p. 103).

WAHLENBERG proposed an explosive consisting of mono, di, or tri-nitro-benzole, chlorate of potash and nitrated alkalies, the latter being preferably treated with solid hydro-carbons to make them non-deliquescent. Nitrate of ammonia was specially recommended, and considerable safety is claimed for the compound. (Spec. No. 2,422, 12. 6. 76).

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[*] Amyline (C_5H_{10}) is a transparent, colourless, very thin liquid, produced by the dehydration of amylic alcohol ($C_5H_{12}O$) or fusel oil.

[†] Inuline ($C_5H_{10}O_5$) is a substance much like starch, prepared from various plants.

[‡] Produced from blast furnace slag by blowing into it when melted. It is much used as a non-conducting material for packing steam pipes, etc.

WOHANKA adds cellulose to the liquid explosives, made by dissolving in concentrated nitric acid the nitro-derivatives of the hydro-carbons of the aromatic phenol series. The cellulose becomes nitrated and swells up, forming with the explosives a plastic mass like gelatine. (Spec. No. 7,608, 25. 5. 87).

WOOD GUNPOWDER, a generic name for NITRO-LIGNIN preparations, *see* also PATENT GUNPOWDER.

XYLOGLODINE consists of glycerine and starch, or glycerine and cellulose, or glycerine and mannite, or glycerine and benzole, or analogous substances treated with the usual acids. It is claimed that it differs in certain characteristics from nitro glycerine. (T., p. 101).

XYLOIDINE, *see* NITRO-STARCH.

CLASS VI.—(PICRIC POWDERS).

This class of explosives essentially consists of picric acid or picrates, and forms a convenient subdivision of the great nitro-compound class, other members of which have been previously enumerated.

Picric (carbazotic or tri-nitro-phenic) acid is a nitro-substitution compound obtained by the action of nitric acid on a variety of substances, *e.g.*, indigo, silk, acaroïd resin (*xanthorrhœa hastilis*), but on the commercial scale the substance now generally acted upon by the nitric acid is carbolic acid, and the equation of the process is simple, viz. :—

$$\underset{\text{Carbolic acid.}}{C_6H_6O} + 3\,HNO_3 = \underset{\text{Picric acid.}}{H \,.\, C_6H_2 \,.\, 3\,NO_2 \,.\, O} + 3\,H_2O.$$

Picric acid may, as written above, be regarded as a picrate of hydrogen, which latter element can be displaced by a metal to form an ordinary picrate, *e.g.*, picrate of potassium ($K \,.\, C_6H_2 \,.\, 3\,NO_2 \,.\, O$). It is a crystalline substance of a brilliant yellow colour, and, as its name implies, is intensely bitter to the taste. It burns with a very smoky flame. It can be detected in very small amount in aqueous solution by adding cyanide of potassium and ammonia, when a red colour, due to the formation of isopurpurate of potassium, is produced.

It is largely used as a dye, or constituent of dyes, and has not been usually considered as an explosive. Nor indeed does it usually behave like one under ordinary circumstances, though under special conditions easily produced it is capable of developing very formidable explosive properties.

It may be burnt away in an unconfined state in considerable quantity without explosion,* but the mere contact of certain metallic salts or oxides with picric acid, in the presence of heat, develops powerful explosives, which are capable of acting as detonators to an indefinite amount of the acid, wet or dry, which is within reach of their detonative influence.

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* Several authorities say that when sharply heated it explodes, but experience and experiment do not seem to bear this out.

A disastrous explosion occurred in 1887 * at a chemical manufactory near Manchester, originating with an accidental fire. This explosion was clearly due to the fulfilment of the conditions expressed in the last paragraph, and was the cause of certain experiments being made, which are specified at length in the report alluded to. The result of these was to show that picric acid could be readily detonated by the action of so small a quantity as five grains of fulminate of mercury applied in the usual way; and that such detonation would extend to wet picric acid, containing at all events 14 per cent. of water. In fact, exposed to detonation, the acid behaved much like compressed guncotton in sensibility and power of transmitting the initial detonation of some of the dry material to the same substance wetted.

No explosion or detonation could be obtained by simply heating or burning the acid; no very *large* amounts were tried, but the burning away of so much as 1,500 lbs. harmlessly has been recorded. When strongly confined the continued application of heat exploded it.

A very crude admixture of metallic oxides or nitrates, notably litharge, lime, and the nitrates of lead, and strontium, with picric acid, will, on the application of heat, detonate, and such detonation will extend to contiguous masses of the unmixed acid. The heat first induces the formation of picrates, and its continued application causes their detonation.

In consequence of this accident, and of the consequent experiments noted above, an Order in Council (No. 14, dated 29th December, 1887) has been made under the 43rd Section of the Explosives Act. The effect of this Order is to bring picric acid within the scope of the above Act, as regards its manufacture and storage, except when :—

(*a*). It is wholly in solution.

(*b*). When it is not wholly in solution, but is being manufactured or stored in a factory, building, or place exclusively appropriated to the manufacture or storage of picric acid, and in such manner as effectually to prevent any picric acid from coming into contact (whether under the action of fire or otherwise) with any basic metallic oxide or oxydising agent, or other substance capable of forming with picric acid an explosive mixture or explosive compound, or with

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* For full report on this, with details, see Colonel Majendie's special "Report to the Rt. Hon. the S. of S. for Home Dept. on the circumstances attending a fire and explosion at Messrs. Roberts, Dale, & Co.'s chemical works, Cornbrook, near Manchester, on the 22nd June, 1887," dated 15. 8. 87.

any detonator or other article capable of exploding picric acid, or with any fire or light capable of igniting picric acid.*

Moreover, all picrates or mixtures of picric acid with any basic metallic oxide, etc., as detailed in (*b*), are to be deemed explosives within the meaning of the Act for *all* † the purposes of the said Act, unless such picrates or mixtures be wholly in solution.

In 1885 M. Turpin took out an English patent ‡ claiming the employment of picric acid as an explosive agent for military and other uses unmixed with any ordinary substance whatever.§ He proposed to compress the acid, to agglomerate and mould it with an aqueous solution of gum arabic, or oils, fats, etc.; or to use collodion jelly. When the last-named substance is diluted in the proportion of from 3 to 5 per cent. in a mixture of alcohol and ether, he states that the blocks of picric acid moulded with it will explode in a closed chamber with a priming of from one to three grammes of fulminate. He also proposed to cast picric acid into projectiles, the cast acid having a density of about 1·6. In shells he dispensed with the use of fulminate, and used, in lieu of it, a priming charge of violent gunpowder (25 grammes) or a powder composed of chlorate of potash, tar, and charcoal.

This invention probably closely resembles *Melinite*, but the exact composition of this explosive is kept secret.

Explosive mixtures containing picric acid with nitrates or chlorates are of very suspicious chemical stability, as the acid is a greedy one, and tends to form picrates, displacing the chloric or nitric acids especially, in presence of moisture. Hence picrates are to be preferred to the acid itself for admixture with such other salts.

ABEL, *see* PICRIC POWDER.

BORLINETTO'S POWDER consists of :—

Picric acid	10	parts.
Nitrate of soda	10	,,
Chromate of potash	8½	,,

It is said to be insensible to friction and percussion. (D., p. 736).

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* When, however, picric acid is manufactured with a view to being used as an explosive, it then falls under the scope of the Act for all purposes thereof in virtue of the provisions of Sec. 3, quoted in the Preface as being "used or manufactured with a view to produce a practical effect by explosion." The exemptions in the Order apply to it when it is destined for other commercial purposes, *e.g.*, calico printing. A similar remark applies to picrates.

† *i.e.* Not merely in case of manufacture and storage like picric acid.

‡ Spec. No. 15,089, 8. 12. 85.

§ Picric acid is very deficient in oxygen, as its formula shows. The productions of its explosion will therefore largely consist of the actively poisonous carbonic oxide, and hence, as a blasting agent, in mines it would be objectionable. In digging out some shells which had been charged with some picric acid explosive and fired into earth, some French soldiers were poisoned by the noxious fumes some time after the shells had been fired and burst.

Bronolithe, the invention of M. Bela de Broncs, consists of various mixtures, mainly consisting of the picrates of lead and sodium and potassium, with the addition of nitro-naphthalene and soot.

This seems to be identical with a series of explosives noted by Munroe (No. XIII., p. 247) as consisting of :—

Barium-sodium picrate	15	to	30	per cent.
Lead-sodium ,,	8	,,	30	,,
Potassium ,,	2	,,	10	,,
Nitro-naphthalene	5	,,	20	,,
Saltpetre	20	,,	40	,,
Sugar	1·5	,,	3	,,
Gum	2	,,	3	,,
Lampblack	0·5	,,	4	,,

The double picrates are obtained by mixing three equivalents of sodium picrate with one of lead or barium picrate.

Samples of this explosive are now (January, 1889) under examination for admission to the authorised list.

Brugère's Powder consists of 54 parts of picrate of ammonia, and 46 of saltpetre. It is stable, safe to manufacture and handle, but rather expensive. It has good results in a Chassepôt rifle. It gives little smoke, and its residue is small, and consists of carbonate of potash. (D., p. 740).

Casthelaz, *see* **Designolle's**.

Chandelon uses organic picrates (such as picrates of benzene, naphthalene, and of their nitro-derivatives) in conjunction with nitrate of ammonium or other nitrates, or with chlorates partially or wholly replacing nitrates. (Spec. No. 13,360, 15. 9. 88).

Designolle's Powders were made in several varieties at Bouchon in 1869, they consisted of :—

	For torpedoes and shells.		For guns.			For small arms.	
			Ordinary.		Heavy.		
Picrate of potash	55	50	16·4	9·6	9	28·6	22·9
Saltpetre	45	50	74·4	79·7	80	65·0	69·4
Charcoal	—	—	9·2	10·7	11	6·4	7·7

These powders were made much like ordinary gunpowder, 6 to 14 per cent. of moisture being added when being milled. The advantages claimed over gunpowder are greater strength, and consequently greater ballistic or disruptive effect, comparative absence of smoke, and freedom from injurious action on the bores of guns, owing to the absence of sulphur. (D., p. 738).

An English patent was taken out in 1867. (Spec. No. 3,469, 5. 12. 67).

EMMENSITE. "Emmens" crystals are produced by treating picric acid with red fuming nitric acid (S. G., 1. 52). The acid dissolves with the evolution of red fumes, and when cooled * yields crystals stated to be different to picric acid. The liquor deposits a second crop of similar crystals and a quantity of lustrous flakes. These flakes, when heated in water, separate into two new bodies, one of these enters into solution and forms crystals unlike the first, while the other body remains undissolved.

The acid crystals and residuum are used in conjunction with a nitrate to form an explosive. (Spec. No. 370, 10. 1. 88). *Journal of Society of Chemical Industry*, December, 1888.

FONTAINE'S POWDERS consist of picrate and chlorate of potash, and are intended for use in torpedoes and shells, but they are obviously very dangerous to manipulate, and caused a terrible explosion in Paris in 1869. (D., p. 739).

HOWITITE. A picric explosive of very unstable character. It was submitted for licensing and rejected. The inventor desired the composition to be considered as confidential.

LITHOTRITE is a Belgian explosive, containing nitrate of soda, saltpetre, sawdust, charcoal, picrate of ammonia, ferrocyanide of potassium and sulphur. Samples, however, recently submitted for examination consist of a simple nitrate mixture composed of saltpetre, sawdust, charcoal, and sulphur. It is a fine grey powder, sometimes made up into compressed cartridges. (Spec. No. 783 of 1887).

MELINITE is an explosive which has recently been experimented with on a large scale by the French Government. Its composition is kept secret, but picric acid is supposed to form its main constituent, and it very possibly much resembles the explosive patented by Turpin, and mentioned in the introduction to this section.†

OXONITE, *see* Class VII.—(Sprengel explosives).

PICRATE OF POTASH has been tried in Austria and America as a charge for shells, but by itself it does not contain sufficient oxygen to burn up the whole of its carbon, and hence requires the addition of some oxydising agent. It is a gold yellow substance, crystallizing in needles. A violent blow or the contact of flame explodes it. Heated gradually to about 600° F., it detonates violently. When containing 15 per cent. of moisture it is safe from ignition by a blow, and only ignites locally on contact of flame. (D., p. 737).

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* This is not very intelligible as the solution of picric acid in nitric acid produces a lowering of the temperatures.

† There is some reason to believe that nitro-benzole or a similar material is employed as well. A portion of the explosive, as used to fill shells, is said to be termed *Crésilite*. Kresylic acid (C_7H_8O) corresponds to carbolic acid, but contains the (hypothetical) radical kresyle C_7H_7 in lieu of phenyle (C_6H_5).

PICRIC ACID, *see* introduction to this section.

PICRIC POWDER is practically the same as Brugère's. It was proposed by Abel for filling shells, and consists of three parts of saltpetre to two parts of picrate of ammonia. It takes a very violent blow to explode it. Unconfined, and on contact of flame, it only burns locally. It requires strong confinement to develop its force.

PUNSHON absorbs nitric acid in asbestos, or other porous substance, and picric acid. A paste is made and put up in paper cartridge cases lined with a cement of ground glass and concentrated solution of silicate of soda to prevent the action of the acid on the paper. (Spec. No. 2,242, 1. 6. 80). *See* also OXONITE.

The same inventor proposes a mixture of picric acid, nitro-glycerine, chlorate of potash, and wood charcoal. (Spec. No. 11,140 of 1887).

TSCHIRNER'S POWDER consists of 57 parts of picric acid and 43 parts of chlorate of potash incorporated together with five per cent. of powdered resin. The product is sprinkled with benzine or kerosene to moisten it and dissolve the resin. The compound becomes a plastic mass, easily moulded, and the solvent evaporates off. (Spec. No. 447, 31. 1. 80, and No. 3,846, 22. 9. 80).

TURPIN, *see* introduction to this section.

VICTORITE somewhat resembles TSCHIRNER'S POWDER. It consists of chlorate of potash, picric acid, and a little olive or other oil, with the occasional addition of some charcoal. It is in the form of a coarse yellowish grey powder, which leaves an oily stain on paper. It is extremely sensitive to friction and percussion. It was submitted for approval in this country and rejected.

In the specification the following proportions are given :—

Chlorate of potash	80	parts.
Picric acid	110	,,
Nitrate of potash, soda, or baryta... ...	10	,,
Charcoal	5	,,

Another variety substitutes nitro-glycerine for chlorate of potash.

CLASS VII.—(SPRENGEL EXPLOSIVES).

The class of explosives now to be considered are those which may all be classed under the patents of Dr. Herman Sprengel, F.R.S.* The essential principle of them all is the admixture of an oxidising with a combustible agent at the time of, or just before, being required for use, the constituents of the mixture being themselves non-explosive.

The idea of forming an explosive by the bringing into contact on the spot two inexplosive substances, or mixtures of explosives, is by no means novel, as may be seen on referring to the chlorate mixture section. It has indeed been proposed to make nitro-glycerine on the spot where it was required, and the process proposed by Gale was simply reversing the order of things, when from his inexplosive mixture of gunpowder and ground glass, he sifted out the explosive, leaving the inert glass behind. But Sprengel follows out a line of thought of his own, and concludes his introductory argument by saying—"Led by the idea that (as a rule) an explosion is a sudden combustion, I have submitted a variety of mixtures of oxidising and combustible agents to the violent shock of a detonating cap. These mixtures were made in such proportions that their mutual oxidation and de-oxidation should be theoretically complete." Some of the mixtures cited by him are liquid, some are solid, others a mixture of a solid and a liquid. Amongst them are the following:—

(*a*) 1 chemical equivalents of nitro-benzene to 5 equivalents of nitric acid.
(*b*) 5 ,, ,, picric acid ,, 13 ,, ,, ,,
(*c*) 87 ,, ,, nitro-napthalene ,,413 ,, ,, ,,
(*d*) Porous cakes or lumps of chlorates of potash exploded—
  (1) most violently with bi-sulphide of carbon.
  (2) ,, ,, ,, nitro-benzole.
  (3) violently ,, $\frac{1}{2}$ benzine + $\frac{1}{2}$ bi-sulphide of carbon.
  (4) ,, ,, bi-sulphide of carbon saturated with napthalene.
  (5) very well ,, carbolic acid dissolved in bi-sulphide of carbon.
  (6) not well ,, $\frac{3}{4}$ petroleum + $\frac{1}{4}$ bi-sulphide of carbon.
  (7) ,, ,, benzine saturated with sulphur.
  (8) not at all ,, benzine alone.

On referring to the annexed alphabetical list it will be seen that:—

(*a*) resembles *Hellhoffite.* Sprengel especially recognising the possible value of employing the di-nitro-benzine.

(*b*) is *Oxonite.* Sprengel says, very truly, that picric acid alone is a powerful explosive when fired by a detonator.

(*d*) Covers all the ground of *Rack-a-rock.*

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* No. 921, 6. 4. 71. No. 2,642, 5. 10. 71. See also Journal of Chemical Society, August and September, 1873. Mr. Silas R. Divine, U.S.A., claims to have invented a mixture of chlorate of potash and nitro-benzole (now termed Rack-a-rock), and on 9th January, 1871, he filed a caveat in the confidential archives of the "United States Patent Office," but published no patent till 1880. To Dr. Sprengel at all events would appear to belong the credit of the first publication, not of one explosive only of the type, but of the general principle underlying them all.

When we come to the practical value of this class of explosives, whose great power cannot be disputed, we have to bring other considerations into play.

For instance, in this country no such explosives are, or can, in the existing state of the law, be licensed as "authorised explosives," supposing that they are to be made on the spot. For such admixture of ingredients to form an explosive for practical use, or for sale, would constitute "manufacture," and could be carried on only in a duly licensed factory. Even supposing this objection to be withdrawn, there would be serious objections to the use of such liquids as nitric acid or bi-sulphide of carbon being mixed in confined spaces, such as mine galleries, etc. In fact the use of such explosives would, as some critic has put it, "require a man to be chemist as well as miner."

All explosives of this class require a detonator. When nitric acid is one of the ingredients the greatest care is necessary to avoid its coming into contact with the explosive contained in the detonator. If such contact takes place a premature explosion is pretty certain, as indeed occurred in a trial with oxonite in August, 1884.

DIVINE'S EXPLOSIVE, *see* RACK-A-ROCK.

HELLHOFFITE is a mixture of nitro-petroleum or nitro-tar oils with nitric acid. One form of it proposed by Gruson has been tried in shells, and consists of meta-di-nitro-benzole ($C_6H_4 \cdot 2NO_2$) and nitric acid. The two substances are placed in separate receptacles in the shell, and are automatically mixed during the flight, or on the impact of the shell, as the case may be. (Spec. No. 1,315, 23. 10. 79; Nos. 1,285-7, 27. 3. 80; and No. 2,775, 7. 7. 80).

OXONITE is a mixture of picric and nitric acids. The picric acid, sometimes with the addition of a nitrate, is packed in a calico cartridge, which also contains the nitric acid in a hermetically sealed glass tube. This tube is to be broken by a blow before putting the cartridge into the bore-hole. This explosive caused a serious accident to the patentee, and another in August, 1884. They were experimenting in (fortunately for them) bore-holes in soft mud. While tamping a cartridge it exploded, very seriously injuring them. There is no doubt that the accident was due to absence of precaution against allowing the nitric acid to gain access to the contents of the detonator, intended, in conjunction with a fuze, to fire the cartridge. (Spec. No. 2,428, 12. 5. 83).

PANCLASTITE is a name given to various mixtures proposed by M. E. Turpin. In some he proposes to mix liquid nitrogen

tetroxide, or nitric peroxide (N_2O_4)* with bi-sulphide of carbon, benzole, petroleum, ether, mineral volatile oils, or other liquid or solid hydro-carbons. He recommends especially a mixture of $2CS_2 + 3N_2O_4$, but the use of two such ingredients, both giving off highly deleterious vapours, is a very serious objection to the use of such a mixture in a mine or other confined space, and the vapour given off by the liquid N_2O_4 is especially dangerous. (Spec. No. 4,544, 1881, and No. 1,461, 27. 3. 82).

M. Turpin also proposed a mixture of about 80 parts chlorate of potash to 20 parts coal tar, with the addition, if necessary, of some porous absorbent for the liquid tar. Two of his powders are as follows :—

	No. 1.		No. 2.	
Chlorate of potash	80	per cent.	40	per cent.
Coal tar	14 to 16	,,	15	,,
Wood charcoal...	4 to 6	,,	5	,,
Nitrate of potash	—	,,	40	,,

These powders are granulated like ordinary powder, or mealed, or used in form of compressed cartridges. (Spec. No. 2,139, 27. 4. 83).

Rack-a-rock consists of compressed cartridges of chlorate of potash, impregnated before use with dead oils or other liquid hydro-carbons, or with nitro-benzole. In the great Hell Gate explosion, which took place on the 10th October, 1885, 240,399lbs. of rack-a-rock were used in conjunction with 42,331lbs. of dynamite.

If the cartridges be kept they appear to tend to increased sensibility to friction or percussion. *See* Chlorate Mixture section on this head, and also heading Rack-a-rock in that section. (Spec. No. 5,584, 21. 12. 81 ; No. 5,596, 21. 12. 81 ; No. 1,461, 27. 3. 82 ; Nos. 5,624-5, 4. 12. 83).

Sprengel, *see* introduction to this section.

Turpin, *see* Panclastite.

Class VIII.—(Miscellaneous Explosives, including Fulminates).

There is little to be said about the explosives noted in this section beyond what is expressed by the name. A good many of them are mere chemical curiosities.

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* N_2O_4 is a gas or vapour which can at low temperatures be solidified. The crystals melt at —9° C., but will not re-crystallise except at a much lower temperature. A little above —9° C., the liquid is colourless, but becomes gradually orange yellow, and boils at 22° C. The vapours are powerfully irritating and highly dangerous.

ALEXANDER proposed to employ in the manufacture of fulminating powder, 83 parts of amorphous phosphorous to 917 parts of nitrate of lead, or other suitable metallic salt. (Spec. No. 1,003, 9. 4. 57).

Identically the same proposal was made by Johnson. (Spec. No. 2,377, 10. 10. 56).

AMMONIO-NITRATE OF COPPER is $4NH_3Cu(NO_3)_2$. It has been patented by Nobel as an explosive when detonated. It is said to be powerful and to give a very short flame of comparatively low temperature. (Spec. No. 16,920, 8. 12. 87).

AMORCES or TOY CAPS are only toy fire-works, and consist of small dots of explosive composition enclosed between two pieces of thin paper (generally pink). The composition, as licensed in England, consists of a mixture of chlorate of potash and amorphous phosphorus, with or without the addition of nitrate of potash, sulphide of antimony, and powdered sulphur. The explosive is limited to 0·07 grains in each cap and the amorphous phosphorus component to 0·01 grains.

These, as above defined, are harmless toys, but if the amounts given are exceeded they are capable of exploding *en masse* and producing a disaster. At Vauves, near Paris, a child was cutting a toy cap with scissors, and thus caused the explosion of two packets containing 600 similar caps on the table. The child was killed. On the 14th May, 1878, in the Rue de Beranger, Paris, six to eight millions amorces, containing explosive to the amount of about 154 grains per 1000, exploded. The house and an adjoining one were destroyed; 14 people were killed and 16 wounded. The total amount of explosive was estimated at about 140lbs.

A comparatively very small amount of amorces exploded on 3rd August, 1888, in one of the sheds of a factory devoted to their manufacture near Wandsworth. Of four girls present, three were killed and the fourth severely injured. The light wooden shed in which the explosion occurred was utterly wrecked. There is no doubt that the accident was due to the accidental detonation, by cutting with scissors or otherwise, of some amorces containing more than the stipulated amount of explosive. These acted as detonators to a number of loose amorces present. It was a parallel accident to the Vauves one quoted above.

ANILINE FULMINANTE is a diazo-benzol compound, prepared by treating nitrate of aniline ($C_6H_5NH_2 \cdot HNO_3$) with nitrous acid ($H \cdot NO_2$) prepared by the action of nitric acid on arsenic tri-oxide. The resulting products are water and diazo-benzol nitrate (aniline fulminante) having the composition $C_6H_5N_2 \cdot NO_3$

HAHN proposed a priming composition for needle guns consisting of:—

Chlorate of potash	20 parts
Picric acid	5 ,,
Amorphous phosphorus	5 ,,
Tersulphide of antimony	1 ,,

made into a paste with water and gum. (Spec. No. 961, 30. 3. 67).

HUNTER'S MINING FUZES are much the same as GERMAN SPILLS, *q.v.*; they are waterproofed or varnished outside. One end of the tube is primed with saltpetre or sulphur, or both. The saltpetre only is best in fiery mines. The manufacture is not at present carried on.

JOHNSON proposed to employ amorphous phosphorus with metallic salts in the manufacture of fulminating powder. His proposal and proportions are identical with those of ALEXANDER, *q.v.* (Spec. 2,377, 10. 10. 56).

METALLIC SAFETY FUZE, *see* SAFETY FUZE.

MEYER and MORITZ proposed a mixture of:—

Fine gunpowder	20 parts
Antimony	1 ,,
Saltpetre	2 ,,

One part of this mixture and five parts of fulminating mercury were to be mixed with half a part of Roman cement, and moistened with gum to form a paste. When dry it was to be waterproofed by means of grease. It is doubtful if this curious mixture was ever really tried. (Spec. No. 515, 23. 2. 65).

MILLBANK proposed as a composition for "caps, primers, and cartridges," two detonating mixtures composed of:—

	1	2
Chlorate of potash	80	20
Prussiate of potash...	—	10
Amorphous phosphorus... ...	4½	1
Charcoal	35	—

He speaks of them as reliable and safe! (T., p. 103).

MINER'S SQUIBS are identical, practically, with HUNTER'S MINING FUZES. The invention was patented by Daddow. (Spec. No. 1,558, 2. 5. 74). They are largely used in the Cleveland iron district.

NITRATE OF TIN merits a mention as being a possible cause of obscure explosions in powder mills. It was found at Spandau that frequent ignition of the powder took place at a certain stage of its manufacture in the Government Powder Mills. On examining the machinery it was found that where bronze pieces which were soldered were in constant contact with the moist powder, the solder was much corroded, and in part entirely destroyed. In the joints a substance had collected, which when scraped out with a chisel exploded with emission of sparks. The matter was examined into and experiments were carried out, and eventually it was found that if a thin layer of sulphur and saltpetre were placed between sheets of tin and copper foil and allowed to remain in a constantly moist condition, after a time the copper was coated with sulphide, and the tin was largely converted into an explosive basic nitrate. The action is probably this: the copper sulphide is oxidised to sulphate which with the saltpetre forms potassium sulphate and copper nitrate. The latter, as shown by independent experiments, can unite with the tin of the solder to form the explosive basic nitrate, which, being insoluble, gradually collects in the joints and finally leads to an explosion. The substance when obtained pure is a white crystalline powder, which explodes violently with a shower of sparks when heated rapidly or subjected to percussion or friction. It is formed when a fine spray of nitric acid (s.g. 1·20) is thrown on a surface of tin or solder, or when tin or solder are exposed to the action of a solution of copper nitrate. (M. No. III., p. 671, *et seq.*).

NITRATE OF DIAZOBENZOLE, *see* ANILINE FULMINANTE.

NITRATE OF ETHYL, or ordinary nitric ether ($C_2H_5 . NO_3$), is the result of treating alcohol with nitric acid. It is liquid, and boils at 172° F. A small quantity of the liquid can be burnt, but the vapour detonates with violence at about 284° F.

NITRATE OF METHYL ($CH_3 . NO_3$) has been proposed as a liquid explosive. It boils at 150° F. The vapour explodes at about 270° F., or in contact with flame, and the detonation is communicated to the liquid ether. This liquid caused an explosion at St. Denis, 12th November, 1874, in this way. It is manufactured for dyeing purposes, and can be produced by acting on an alcoholic solution of nitrate of urea with nitric acid, or by distilling wood spirit with saltpetre and sulphuric acid.

In 1863 Nobel proposed to mix nitro-glycerine, or the nitrates of ethyl and methyl with gunpowder, guncotton, or other analogous substance. (Spec. No. 2,359, 24. 2. 63).

Nitrogen Chloride (NCl_3) is an oily liquid of a most dangerously sensitive and explosive character, and practically unmanageable for use. It is made by allowing chlorine to act on a solution of ammonium chloride.

Nitrogen Iodide ($NH . I_2$) is a black powder which explodes at the touch of a feather when dry. It is formed by the action of ammonia on iodine.

Nitrogen Sulphide (N.S.), is a yellow crystalline substance obtained by passing ammonia through a solution of protosulphide of chlorine in di-sulphide of carbon. It readily explodes by percussion or when heated to about 400° F.

Perkins proposed the use of amorphous phosphorus with metallic sulphides, especially of antimony, and chlorate or nitrate of potash, for fulminating powders. (Spec. No. 898, 28. 3. 70).

Preisenhammer proposed a mixture of hydrogen and oxygen gases for blasting. (Spec. No. 3,377, 23. 9. 61). This idea has been revived by Edison for land mines (M. No. VII., p. 114), and also, I believe, from time to time by other persons. Of course, if solid or liquid mixtures of these gases could be preserved till required for use, we should have a most powerful and valuable explosive, but unfortunately the difficulties in the way of such a course appear, to our present knowledge, insuperable.

Railway Fog-signals are usually flattish circular tin or tinned iron cases, containing a small quantity of powder, and nipples armed with ordinary percussion caps. They are secured to the rails by soft lead clips, and the weight of a locomotive wheel passing over them fires the caps, and consequently the powder. They are in this country required to be of such strength and construction that the explosion of one will not cause the explosion of similar ones contiguous to it.

Rave proposed to press a current of chlorine produced by the action of hydro-chloric acid on di-oxide of manganese into a mixture of 80 parts of carbonate of potash, 30 parts of ground straw, and 15 parts of anthracite, made into a thin paste with water. The resulting mixture was to be dried and used as a blasting powder. Of course this is simply a chlorate of potash mixture obtained in a round-about way. (Spec. No. 2,469, 23. 11. 59).

Safety Cartridges are defined by Sec. 108 of the Explosives Act, 1875, to be "cartridges for small-arms, of which the case can "be extracted from the small-arm after firing, and which are "so closed as to prevent any explosion in one cartridge being "communicated to other cartridges." For instance, ordinary service small-arm and sporting cartridges are safety cartridges.

Safety Fuze is defined in Order in Council, No. 1, made under Explosives Act, 1875, to be "a fuze for blasting which burns "and does not explode, and which does not contain its own "means of ignition, and which is of such strength and construction, and contains an explosive in such quantity, that "the burning of such fuze will not communicate laterally "with other like fuzes." It is commonly called "Bickford fuze," but there are many varieties and several makers, who in most cases have a trade mark consisting of one or more white or coloured threads down through the interior column of powder.

Toy Caps, *see* **Amorces**.

Tube Safety Fuze is a recently licensed variety of metallic safety fuze.

Volney's Explosive is produced by saturating concentrated glycerine ($C_3H_5(OH)_3$) with hydrochloric acid gas to form glycerine chlorhydrin ($C_3H_5 . (OH)_2C_2$) which is treated with a mixture of nitric and sulphuric acids to form mono-chlordinitrin ($C_3H_5 C_2 . 2NO_2$). (T., p. 107).

Weniger, *see* **Preisenhammer**.

Winiwarter's fulminating compositions consist of :—

	No. 1.
Fulminate of mercury...	300 parts
Chlorate of potash	288 ,,
Sulphide of antimony	312 ,,
Charcoal 16·7 Saltpetre 65·3	60 ,,
Ferro-cyanide of potassium	23 ,,
Binoxide of lead	6 ,,
Solution of 75 parts pyroxilin in 150 parts of ether, called by him ether-oxylin	900 ,,

	No. 2.
Fulminating zinc ...	75 parts.
Chlorate of potash ...	4 ,,
Sulphide of antimony	7 ,,
Binoxide of lead ...	15 ,,
Ether-oxylin	224 ,,
Ferro-cyanide of potassium	1 ,,

	No. 3.
Amorphous phosphorus ...	75 parts
Binoxide of lead	64 ,,
Charcoal and saltpetre ...	15 ,,
Ether-oxylin	106 ,,

(Spec. No. 13,935, 29. 1. 52., and No. 306, 4. 2. 53).

CONCLUSION.

The lists of explosives given in the foregoing sections are long, but the list of explosives actually practically in use in this country is but small. They are :—

Gunpowder in its numerous forms,
Guncotton under various names and usually nitrated,
Dynamite No. 1,
Blasting gelatine,
Gelatine dynamites,

and some supplementary explosives, such as fulminates for detonators and percussion caps.

Of the di-nitro-benzole and nitrate of ammonia mixtures only one, roburite, is at present (January, 1889) manufactured in this country on a commercial scale. Steps are, however, being taken with a view to the introduction of securite, bellite, and similar compounds.

I would finally add a few words of caution :—

1. The function of an explosive is to explode. Remember this in dealing with them.
2. If an explosive is described as absolutely safe under all circumstances, do not treat it as some people treat a big dog, and try how much it will stand. Under these circumstances both explosive and dog are apt to bite. Prefer to see the truth of such assertions tested by the manufacturer or his agent rather than by yourself.*
3. There is no explosive within my knowledge in practical use which when exploded in a confined space does not give off noxious or deleterious gases.
4. Do not expect the same class of explosive to do every variety of work. Different classes have their different functions, just as a chisel and a gimlet are both useful tools but will not do each other's work.
5. If using an explosive with which special instructions (*e.g.* as to thawing dynamite) are issued, it is wiser to read them before an accident happens than to have to refer to them after the accident to see if they are not, after all, issued for some good reason and meant to be studied.
6. Do not apply the sense of taste to explosives. In the case of some, such as nitro-glycerine and nitro-benzole compounds, the consequences may be unpleasant. Unnecessary handling of the exposed explosive should also be avoided.

---

* Of course I do not refer to experiments properly and scientifically conducted, but to rash and useless show-off trials.

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It crystallises out from ether and alcohol in long colourless needles, and is a very unstable compound, especially under the influence of moisture. When exposed to daylight it turns pink, and slowly decomposes. It is as sensitive to friction and percussion as fulminate of mercury. Heated to about 200° F. it explodes violently. It has been proposed for use in percussion caps, but is far too unstable.

Benedict's Powders are proposed for use in caps instead of fulminate of mercury. They are "single" and "double," and have respectively the following composition :—

	Single.	Double.
Chlorate of potash	12	9
Amorphous phosphorus ...	6	1
Lead oxide	12	—
Rosin	1	—
Sulphide of antimony ...	—	1
Sublimed sulphur	—	0·25
Saltpetre	—	0·25

(M. No. V., p. 752).

Bichel distils hydro-carbons, such as resin oil, wood or coal tars, with sulphur, and mixes the resulting product with nitrates or chlorates, or nitro-compounds. He claims that the admixture with nitro-glycerine, etc., is readily made, and results in a stable compound. (Spec. No. 14,623, 11. 11. 86, amended 5. 10. 88).

Bousfield proposed fulminate of mercury and collodion as a detonating compound. (Spec. No. 2,882, 17. 11. 57).

Canouil's cap composition consisted of :—

Chlorate of potash	100	parts.
Powdered glass	100	,,
Hydro-sulphite and cyano-ferrique of lead	80	,,
Amorphous phosphorus	2	,,
Water	200	,,

The ingredients to be separately powdered, and mixed with the water to form a paste. (Spec. No. 970, 18. 4. 60).

Cap Composition. The composition for percussion caps varies a good deal with the quality and object of the cap. That used for English Government caps consists of :—

Fulminate of mercury	6	parts.
Chlorate of potash	6	,,
Sulphide of antimony	4	,,

and in some special caps two parts of ground glass are added to the above. Some cheap caps contain no fulminate.

CARO, *see* ANILINE FULMINANTE and CHROMATE DE BENZINE.

CASTHELAZ, *see* DESIGNOLLE.

CHROMATE DE BENZINE DIAZOTÉE is one of a general class of fulminating substances proposed by Caro and Griess. Amido-compounds are separated from their solutions by treating them with a mixture of hydro-chloric and chromic acids, or with the latter only, so as to obtain "a crystallised precipitate consisting of a compound of hydro-chloric acid and chromic acid, with the nitrogenised bodies, or of compounds of the latter with chromic acid only."

The process is stated to be the mixing of one equivalent of hydro-chlorate of aniline with two equivalents of hydro-chloric acid. The product is treated with nitrite of lime, and the chromate is precipitated by adding a mixture of one equivalent of acid chromate of potash with one equivalent of hydro-chloric acid. (Spec. No. 1,956, 28. 7. 66, and D., p. 742).

COLLIERY SAFETY LIGHTERS are an ingenious little arrangement for igniting safety fuze. The idea is the crushing of a tiny glass bead or tube containing sulphuric acid and embedded in a chlorate mixture. The acid ignites the latter, which in turn ignites the fuze, on to which the "lighter" contained in a metallic tube fits. Pinching the tube breaks the glass, and releases the acid. The object is to prevent the emission of flame or sparks when using the fuze in fiery mines. They are a revival of the old "Promethean match" with modifications.

COMBUSTIBLE CORD (A. Quentin) consists of a paste of nitro-glycerine, meal powder, and glycerine, intimately mixed together and made into fuze in paper tubes with india-rubber solution. The amount of glycerine regulates the rate of burning. (Spec. No. 1,805, 6. 5. 78).

DADDOW, *see* MINERS' SQUIBS.

DESIGNOLLE and CASTHELAZ proposed a variety of detonating powders consisting of two classes, one for general purposes, the other for "fulminating primings." In the latter class the oxidising effects of chlorate of potash are stated to be overcome by the addition of salts of lead. The following proportions are given :—

	Class I.		Class II.				
	1	2	1	2	3	4	5
Picrate of potash	55	35	37	20	—	—	—
Chlorate of potash	47	47	18	18	16	26	50
Iso-purpurate* of potash...	—	-	—	—	—	—	50
Ferro-cyanide of potassium	—	18	—	—	—	—	—
Chromate of lead	—	—	45	49	41	35	—
Picrate of lead	—	—	—	—	43	37	—
Charcoal	—	—	—	3	—	2	—

(Spec. No. 3,469, 5. 12. 67).

DETONATORS are, as commercially used, metallic capsules, usually of copper, and resemble very long percussion caps. There are eight sizes usually made, which vary in dimensions and in the amount of explosive contained in them. The explosive is pure fulminate of mercury, or a mixture of the same with chlorate of potash and occasionally other substances. They are further distinguished as singles, doubles, trebles, etc., according to their number :—

No.	1	contains	300	grammes	of explosive	per 1000
,,	2	,,	400	,,	,,	,,
,,	3	,,	540	,,	,,	,,
,,	4	,,	650	,,	,,	,,
,,	5	,,	800	,,	,,	,,
,,	6	,,	1000	,,	,,	,,
,,	7	,,	1500	,,	,,	,,
,,	8	,,	2000	,,	,,	,,

As a rule "trebles" are used for ordinary dynamite, stronger ones (5, 6, or 7) for guncotton, blasting gelatine, roburite, etc. It is very false economy to use too weak a detonator or cheap flimsy fuze.

DI-NITRO-GLYCOL is a liquid much resembling nitrate of methyl, *q.v.* Glycol is ethylene alcohol $C_2H_4(OH)_2$ and the di-nitro-glycol is $C_2H_4(NO_3)_2$ and hence is a nitric ether.

FOURNIER proposed as an explosive a mixture consisting of :—

Carbonate of lime	125 parts.
Chloride of sodium	65 ,,

Urine, enough to cover the above when in a vessel.

The mixture was evaporated nearly to dryness, and subsequently mixed with 35 parts of charcoal. This curious mixture was to be used as a substitute for gunpowder. (Spec. No. 507, 21. 2. 70.)

FULMINATES are metallic salts of a hypothetical fulminic acid, or fulminate of hydrogen, and are of the formula $C_2N_2M_2O_2$ where M denotes a monatomic metal. They all explode violently when heated or struck, and are single or double fulminates according to whether one or more metals are contained in them.

* $C_8H_4KN_5O_6$
H

FULMINATE OF COPPER forms highly explosive green crystals, and is obtained by boiling fulminate of mercury (or fulminate of silver, in which case a greenish blue powder is obtained) with copper and water.

There are also double fulminates of copper and ammonium, and of copper and potassium.

FULMINATE OF MERCURY is the fulminate by far the most in practical use. It is produced by the action of alcohol on mercury dissolved in nitric acid. When pure it is white, but is often greyish or yellowish. It is extremely explosive and has very violent local action. It explodes with slight friction or percussion, or when heated to about 360° F. When thoroughly wet it is inexplosive. The larger the crystals the more sensitive is the fulminate.

FULMINATE OF SILVER is used in bon-bon crackers and other toy fireworks in minute quantities. It is prepared by much the same process as fulminate of mercury, *i.e.*, by the action of alcohol on a nitric acid solution of the metal. It is more sensitive than fulminate of mercury, and can, it is stated, even be exploded under water by friction with a glass rod. It forms small white needles. It forms an intensely sensitive and powerful fulminate with ammonium, and several other metals, that with hydrogen is the acid fulminate of silver.

FULMINATE OF ZINC is obtained by boiling fulminate of mercury with zinc, and it forms an acid fulminate with hydrogen, and double fulminates with many metals.

FULMINATING GOLD is a violently explosive buff precipitate formed when ammonia is added to ter-chloride of gold. It is an ammonium compound, in which part of the hydrogen of the ammonium is replaced by gold.

FULMINATING PLATINUM is a violently explosive black precipitate formed by mixing ammonia with a solution of binoxide of platinum in dilute sulphuric acid. It is, generally speaking, of the same chemical nature as fulminating gold.

FULMINATING SILVER (as distinguished from FULMINATE OF SILVER) is a similar compound obtained by the action of ammonia on oxide of silver. It is very violently explosive.

GERMAN SPILLS are paper tubes containing a little fine-grained gunpowder, and are primed at one end with touch paper. They are used as fuzes instead of "straws" for firing charges of gunpowder in blast-holes.

GRIESS, *see* CHROMATE DE BENZINE.

[illegible] = [illegible]

3

6

ADDENDA TO "DICTIONARY OF EXPLOSIVES."

BY MAJOR J. P. CUNDILL, R.A.

Corrections and Additions, 1890.

---

p. xii.—Mr. Guttman informs me that the "lead test" was originated by Herr Trauzl, based on experiments by Captain Beckerheim in compressed tissue paper.

p. xvi.—Professor A. G. Greenhill, F.R.S., was good enough to discuss with me, in October, 1888, the question of the effects of explosion at a distance, and the results may be summed up as follows.

The sphere of gases suddenly formed on explosion will vary in radius as the cube root of the weight of explosive.

Setting aside the effects within this radius, which is practically "range of flash," Mr. Greenhill considers that the effect (as measured by the impulsive pressure) (E) of explosion varies as the square root of the weight (P) of explosive divided by the distance (D). Thus

$$E = m\,\frac{P^{\frac{1}{2}}}{D}$$

where m is a constant.

For example, if a given effect is produced at 1,000 yards by the explosion of nine tons—

$$E = m\,\frac{(9)^{\frac{1}{2}}}{1{,}000} = \frac{3\,m}{1{,}000}.$$

If the amount be 100 tons, and x be the distance at which the explosion of this amount will produce the same effect as nine tons at 1,000 yards, then

$$E = \frac{m\,(100)^{\frac{1}{2}}}{x} = \frac{m\,(9)^{\frac{1}{2}}}{1{,}000}.$$

$$\therefore \quad x = 3{,}333 \text{ yards.}$$

But this applies strictly to cases where explosion takes place in an incompressible medium, *e.g.*, water at a great depth.

Mr. Greenhill thinks, however, that it may, for practical purposes, be applied to explosions in air.

It is hardly necessary to add that, in practice, the local accidents of the ground, the parts of ignition of the mass, and other circumstances, will greatly modify the above, and abnormal effects may often be produced by the evolution of vortex sheets shot out from the envelope of the suddenly formed body of gases.

p. 4.—MONTRAVEL adds di-nitro-benzole to the ingredients of gunpowder. The mixture is heated to 140°, when the di-nitro-benzole and sulphur melt and form a waterproof protecting film over the grains. (Spec. No. 5,031, 22. 4. 89). See also FORTISINE, p. 12, and WIENER, p. 6.

p. 7.—Mr. Deering gives as the equation of decomposition of amide powder—

$$2\,K\,.\,NO_3 + 2\,NH_4\,.\,NO_3 + 6\,C = K_2CO_3 + 5\,CO + 4\,H_2O + 6\,N.$$

The compositions deduced from the two equations are practically the same.

p. 7.—AZOTINE. A mixture of nitrate of soda, sulphur, coal, and petroleum residue. It is manufactured in Hungary. (O.G.).

p. 8.—BRANDEISL'S POWDER consists of 16 parts saltpetre, 2 of sulphur, and 3 of sugar.

p. 10.—EISLER'S POWDER consists of nitrate of soda, 70·1; sulphur, 17·6; charcoal, 12·25; sugar, 1·2; ashes, 1·2; moisture, 0·83. (O.G.).

p. 10.—FITCH, *see* STARCH POWDER, p. 17.

p. 11.—GEMPERLE. The proportions of the ingredients named are, respectively, 73, 8, 8, 10, and 1.

The compound is also called AMIDOGÈNE, and is made in Switzerland. (O.G.).

p. 12.—HALOXYLINE. Another explosive under this name was introduced by Anders and Fehleisen, and consists of saltpetre, 75 parts; sawdust, 15; charcoal, $8\frac{1}{3}$; and red prussiate of potash, $1\frac{2}{3}$ parts. It is made in Austria. A variety made in Hungary contains nitrate of soda.

p. 12.—In the manufacture of FORTIS No. 2 most of the ingredients are mixed with water, and heated for some time, after which the two remaining ingredients, viz., glycerine and naphthalene, are added. As the result of this heating in presence of water the free sulphuric acid acts on the nitrate, liberating HNO_3, which in turn acts on the sulphate of iron and oxidises it to oxide of iron, provided that the heating is continued long enough. In this case no free acid is left, nor is any liable to be generated.

p. 12.—FORTISINE (originally termed Fortis 3 and 4) consists of a mixture of saltpetre, sulphur, and charcoal, with the addition of di-nitro-benzene and resin (or dextrine). The amount of di-nitro-benzene is not to exceed 4 per cent. of the finished explosive, and all the ingredients are to be thoroughly purified.

p. 12.—HARDY'S POWDER consists of

	"000."	"00."	"0."
Nitrate of soda	46	78·58	76·66
,, potash	21	18·20	19·83
Sulphur...	15	10·5	13·00
Charcoal	15	15·0	17·00
Sugar and tartar..	2·65	6·3	2·80
Moisture	0·35	1·60	0·71

(O.G.).

p. 12.—HIMLEY, *see* also p. 25.

p. 12.—JOHNITE, also called JAHNIT, and made in Austria. The proportions sometimes vary from what is given, and picric acid and calcined soda are added in small quantities.

p. 12.—LIESCH'S POWDER, also called PETRALIT, consists of nitre, sulphur, wood-pulp, and coke-dust. It is made in Hungary. (O.G.).

p. 12.—LEDERIT (Jno. Waffen) is made in Austria, and consists of 45 parts of nitre, 15 of sulphur, 20 of red lead, 18 of leather cuttings, and 2 of picric acid. (O.G.).

p. 14.—NOBEL, also by Spec. No. 1,469, 31. 1. 88, a mixture of charcoal and nitrate of barium with picrate of ammonia or amorphous phosphorus. The last two ingredients are added to counteract the slow combustion inherent in nitrate of barium powders.

p. 14.—PETRALITE, made at Fahlun in 1879, consists of 64 parts of nitrates of potash or soda, 30 of nitrated wood or charcoal and 6 of ammonium carbonate.

p. 15.—REUNERT, *see* STARCH POWDER, p. 17.

p. 15.—ROBANDIS POWDER (or BRISE-ROCS) consists of 70 parts of nitrate of potash, 20 of nitrate of soda, 15 of sulphur, 1 of salt, 5 of coal, and 15 of spent tan and sawdust. (O.G.).

p. 17.—STARCH POWDER. To the ordinary ingredients of gunpowder 2 to 5 per cent. of starch is added. If the charcoal and sulphur be boiled in a solution of nitre and starch, a hard and less hygroscopic powder is produced; but, like all powders prepared in this way, the mixture is not uniform. (O.G.).

p. 17.—SULPHURITE consists of 62 parts of saltpetre, 30 of sulphur, 4 of charcoal, and 4 of wood ashes. (H.M.).

p. 17.—VULCANITE (Köppel) consists of 35 parts of nitrate of potash, 19 of nitrate of soda, 11 of sulphur, 9·5 of sawdust, 9·5 of chlorate of potash, 6 of charcoal, 2¼ each of sulphate of soda and sugar, and 1·26 of picric acid. It is an Austrian explosive. (O.G.).

p. 17.—WETZLER POWDER consists of 66·68 parts of nitrate of soda, 11·77 of sulphur, 18·71 of spent tan. (O.G.).

p. 18.—XANTHINE POWDER is due to Professor Schwarr, of Gratz.

p. 21.—CORNET POWDER consists of 75 parts chlorate of potash to 25 resin. (O.G.).

p. 21.—CYCENE, *see* KITCHEN, p. 26.

p. 21.—DIRIPSITE. Two samples of an explosive bearing this name were submitted in 1889. The first was rejected for extreme sensibility to friction and percussion, the second for want of chemical stability. It was a chlorate explosive, but the inventor desired its composition to be considered confidential.

p. 23.—FRAENCKEL places a cartridge of chlorate of potash in a waterproof cover inside a waterproofed nitrate of ammonium cartridge. The mechanical idea is similar to that of Favier (see p. 73). He also coats a nitrate or nitrates with 2 parts naphthalene to 1 part paraffin, stirring well together, and when required for use mixes with chlorate of potash. (Spec. No. 13,789, 27. 7. 89).

p. 25.—HART proposed chlorate of potash granulated and impregnated with a saccharine solution, or other suitable hydrocarbon liquid. (Spec. No. 9,164, 23. 6. 88).

p. 25.—HIMLEY mixes 45 parts of chlorate of potash with 35 of nitre and 20 of coal tar. The tar is dissolved in petroleum ether, and the latter evaporated off. It is made in Russia. (O.G.).

p. 26.—KITCHEN submitted a sample of an explosive named CYCENE, consisting of 8 parts of chlorate of potash, 3 of coal-dust, and 1 of resin or sulphur. It proved to be sensitive to friction or percussion after keeping. (Spec. No. 11,102, 1889).

p. 27.—MICHALOWSKI. The third ingredient is usually bran. (O.G.).

p. 29.—Last word, for "chlorate" read "chromate."

p. 31.—Saulaville and Laligant make two mixtures, viz. :—

(*a*). Bisulphate of potash or soda	36·06	parts.
Nitrate ,, ,,	28·60	,,
Glycerine	9·20	,,
(*b*). Inflaming matter (calorigène)—		
Chlorate of potash or soda	50 to 55	,,
Coal	50 to 75	,,

The salts are dissolved, the coal admixed, the mixture dried, and the glycerine added. (O.G.).

p. 32.—Sjöberg's Explosive consists of nitrate or oxalate of ammonia, 50 parts; astral oil, 10 parts; naphthalene, 5 parts; and chlorate of potash, 35 parts. Sometimes 5 parts of chlorate of potash are replaced by an equal amount of carbonate of ammonia. (M. XX., p. 300).

p. 32.—Sederolit. A mixture of chlorate of potash, sulphide of antimony, and sulphur. Simply a detonating powder. (H.M.).

p. 32.—Turpin, also Spec. No. 4,544, 18. 10. 81. A disclaimer restricts the claim to mixtures of liquid nitrogen, tetroxide and bisulphide of carbon. See p. 93. Varieties for production of light he calls Selenophanite and Heliophanite. In subsequent disclaimers he gives up the latter and claims Panclastite (p. 92) only.

p. 32.—Last line but one, dele "of potash."

p. 34.—Line 9, Mr. Guttmann informs me: "It was expressly stated to me by the late Mr. Sobrero that he made his invention in Turin, where he was professor, and not in the laboratory of Pelonze. Sobrero gave the name of pyroglycerine, and in Avigliana there is still a small quantity kept, and every year tested, of his original nitroglycerine."

p. 38.—Nobel also proposed to dilute nitro-glycerine with half its weight of tar oil to render it inexplosive. Of this mixture 150 parts are to be shaken up with 100 parts of oleic acid to render it explosive when required. The oleic acid dissolves the tar oil, but not the nitro-glycerine. (Spec. No. 5,252, 28. 4. 85).

p. 40.—Line 3, for "of" read "or"; and add at end of para.:—Some brands contain roasted flour.

p. 40.—AMERICANITE, a term applied to an "insensitive nitro-glycerine" used by S. D. Smolianoff. It is a mixture of 80 per cent. of nitro-glycerine with a secret fluid mixture. (M. XV., p. 573, and XXI., p. 423).

p. 40.—AMIDOGÈNE, see also GEMPERLÈ, p. 11.

p. 41.—ARLBERG DYNAMITE consists of 65 parts of nitro-glycerine absorbed in 35 parts of 'guhr, barium nitrate, and charcoal.

p. 41.—BLASTING GELATINE. For a paper on the manufacture, by Mr. McRoberts, F.C.S., see *Jour. Soc. Chem. Ind.*, Vol. IX., p. 265 (March, 1890).

p. 41.—BALLISTITE is licensed as consisting of nitro-cotton combined with thoroughly purified nitro-glycerine, with or without the addition of camphor or aniline, in such proportions that the whole shall be of such character and consistency as not to be liable to exudation or liquefaction.

An original definition was: nitro-glycerine and nitro-cotton, with or without camphor, benzole, aniline, or similar substances, to be incorporated with nitrates, per-chlorates, or chlorates of potash, soda, or ammonia.

Practically, it is a blasting gelatine containing a large proportion of nitro-cotton, so as to render it slow enough to be used (as its name implies) as a propelling agent.

The latest definition also includes "such other substances as may from time to time be authorized by a Secretary of State." In appearance it is a somewhat Protean substance, as some samples look like "everlasting cloth," others like shoe-leather, and others like caramels.

p. 42.—CAMPHORATED GELATINE is a special mixture of blasting gelatine and camphor.

p. 45.—Mr. Guttman informs me that Coad's Explosive is identical with Rhexite, p. 60.

p. 51.—EXTRA DYNAMITE is made by some Continental factories, and consists of 48·4 parts of nitro-glycerine, 1·6 of nitro-cotton, 34·5 of nitrate of ammonia, 5 of nitrate of soda, 9 of rye flour, 1 of soda, and ½ of ochre.

p. 51.—FORCITE is now defined as consisting of thoroughly purified nitro-glycerine, thickened by being combined with nitro-cotton and mixed or incorporated with wood meal and nitrate of potassium, in such proportions that the whole shall be of such character and consistency as not to be liable to liquefaction or exudation. It is simply a gelatine dynamite.

p. 51.—FULGURITE was also manufactured in Hungary, consisting of nitro-glycerine absorbed in carbonate of magnesia. (O.G.). See NITRO-MAGNITE, p. 58.

p. 53.—GRAYDON soaks woollen or cotton cloth in nitro-glycerine till saturated. The whole is coated with paraffined paper cemented to the cloth, or with shellac, or any coating which will prevent the exudation of the nitro-glycerine. The cloth may be in sheets or ribbons, and charges are made by rolling up the fabric into cylinders. When in ribbons the charges may be made up by placing the tape-like discs on each other. (M. XXI., p. 491, *q.v.*, for other devices by same inventor).

p. 55.—LANDSDORF mixes 75 parts of nitro-glycerine with 5 of ammonium urate and 20 of kieselguhr.

He also employs a mixture of 73 parts of saltpetre to 9 parts each of ammonium urate, sulphur, and charcoal.

p. 55.—KUHNT, add Spec. No. 5,949, 21. 4. 88.

p. 55.—LIEBERT adds 3 to 5 per cent. of iso-amyl-nitrate to nitro-glycerine, or nitrates an emulsion of glycerine and iso-amyl-nitrate, or iso-amyl-alcohol. He claims that this will not freeze at −35°, and that it is less sensitive and more powerful than nitro-glycerine. (Spec. No. 5,503, 30. 3. 89).

p. 55.—LIGNOSE is also a name given to nitrated wood as made in a Prussian factory.

p. 56.—Matagnite. The two following explosives are now licensed thus:—

Blasting Matagnite, consisting of nitro-cellulose carefully washed and purified, combined with thoroughly purified nitro-glycerine, and thoroughly purified nitro-benzole, or either of them, in such proportions that the whole shall be of such character and consistency as not to be liable to liquefaction or exudation.

Matagnite Gelatine, consisting of thoroughly purified nitro-glycerine, and thoroughly purified nitro-benzole, or either of them, thickened by being combined with nitro-cellulose carefully washed and purified, and mixed or incorporated with wood meal for the bleaching or purifying of which no chemical agents have been used, or if used have been absolutely removed and nitrate of potassium, or such other nitrate as may for the time being be sanctioned by a Secretary of State, in such proportions that the whole shall be of such character and consistency as not to be liable to liquefaction or exudation.

p. 58.—Nitro-magnite, see also Fulgurite, p. 51.

p. 60.—Rhexite. A form of this manufactured at St. Lambrecht, in Styria, consists of 67 parts of nitro-glycerine, 11 of decayed wood, 4 of wood-pulp, and 18 of nitrate of soda (O.G.). See also Coad's Explosive, p. 45.

p. 60.—Safety Dynamite. For "3 per cent.," read "5 to 10 per cent." It has been defined for licensing as consisting of not more than 75 parts by weight of a thoroughly purified mixture of nitro-glycerine and nitro, or di-nitro-benzene, or both of them, uniformly mixed with 25 parts by weight. The remainder of the definition is identical with that for Dynamite No. 1. See p. 47.

p. 62.—Waffen's Dynamite consists of—

Sodium nitrate	22·50	60 parts;		
Decayed wood, well dried	36·00	and		
Picric Acid	0·25			
Sulphur	1·00	40 parts of	Nitro-glycerine	94·0
Sodium carbonate	0·25		Collodion	6·0

(M. XXI., p. 503).

p. 63.—Line 17, for "Sieuth," read "Sierch".

The Anzin Company are stated to have consumed more than 30,000 kilos of "safety explosives," consisting of—

	A	B	C
Gelatinised nitro-glycerine	20	30	—
Ammonium nitrate	80	70	90
Octometric guncotton	—	—	10

and find the results favourable. (*Colliery Guardian*, 30. 5. 90).

p. 63.—GRISOUTITE (*grisou*, fire-damp) is another name for Wetter Dynamite, p. 62.

p. 63.—WANKLYN mixes 2 to 5 parts of dynamite or guncotton with 1 part of nitrate of urea. (Spec. No. 9,799, 5. 7. 88).

p. 63.—WHITE DYNAMITE (Diller) consists of 70 parts of nitroglycerine to 19·35 of limestone "guhr" and 10·65 of wood-pulp. The limestone "guhr" is a calc tuff found in stalactitic caverns, etc.

p. 66.—THAWING DYNAMITE. From the winter of 1872 to February, 1890, 63 accidents are recorded at the Home Office as resulting from improper methods of thawing dynamite, etc. The results were 50 deaths and 76 persons injured, *i.e.*, an average of two persons killed or wounded per accident. *Reasonable care would have avoided every one of them.*

p. 70.—ACAPINA resembles Schultze powder. It is made at Bologna for sporting purposes.

p. 70.—AMMONITE. The present name of what was called "Miners' Safety Explosive." See p. 73.

p. 71.—BAUTZEN POWDER consists of equal parts nitrated wood and nitre. (O.G.).

p. 72.—CARBONITE, and a kindred preparation, called STONITE, are now licensed as follows :—

CARBONITE, consisting of not more than 25 parts by weight of thoroughly purified nitro-glycerine, with or without the addition of not more than half a part of sulphuretted benzole, uniformly mixed with 75 parts by weight of a pulverized preparation consisting of wood meal, not less than 40 parts; nitrate of potassium and nitrate of sodium (or either of them) not more than 34 parts; and carbonate of sodium not more than half a part, such preparation to be sufficiently absorbent when mixed in the above proportions to prevent exudation of nitro-glycerine.

STONITE, consisting of not more than 68 parts by weight of thoroughly purified nitro-glycerine, uniformly mixed with 32 parts by weight of a preparation consisting of nitrate of barium, nitrate of potassium (or either of them), kieselguhr (not less than 20 parts by weight), wood meal (not less than 4 parts by weight), and carbonate of magnesia, with or without the addition of sulphuretted oil and soot (or either of them), such preparation to be sufficiently absorbent when mixed in the above proportions to prevent exudation of nitro-glycerine.

p. 73.—EXTRALITE consists of nitrate (50) and carbonate (5) of ammonia, with liquid (10) and solid (5) hydro-carbons and chlorate of zinc (50). (H.M.).

p. 74.—HENGSTITE consists of straw-pulp treated with acids and afterwards with alkalies. It is a fine fibrous substance which is granulated for military and sporting purposes, and compressed for blasting purposes. It is claimed to be smokeless, non-fouling, and non-heating.

This is, of course, simply nitro-cellulose made from straw. (Spec. No. 13,656, 21. 9. 88).

p. 75.—MINERS' SAFETY EXPLOSIVE is now called AMMONITE.

p. 82.—C. Roth gives as the equation of explosion of roburite—

$$C_6H_3Cl\,(NO_2)_2 + 9\,NH_4\,.\,NO_3$$
$$= 6\,CO_2 + 19\,H_2O + N_{20} + H\,.\,Cl.$$

p. 82.—To meet the difficulty of detonating roburite and similar explosives when compressed, Trench proposed to mix nitro-cellulose with them. (Spec. No. 18, 241, 13. 12. 88).

p. 82.—Skoglund proposes explosives consisting of nitro-cellulose or picric acid, with carbonate, oxalate, or carbonate of ammonia, or other volatile base, or hydroxyl. (Spec. 18,362, 15. 12. 88).

p. 82.—Schückher mixes 50 parts of nitro-starch with 40 of nitre and 10 of benzole, or with other nitrates or picrates. The nitro-starch (xyloidine) is treated with a solvent during the process to harden the finished product. (Spec. 11,665, 22. 7. 89).

p. 82.—Sayers mixes nitro or di-nitro-benzene or other nitro-derivatives of hydro-carbons with a suitable proportion of nitrates and gelatinises them with 2 per cent. to 10 per cent. of guncotton. (Spec. No. 17,212, 27. 11. 88).

p. 83.—The "Smokeless Powders" now constitute a very large group. They may, for all practical purposes, however, be divided into two classes, one containing nitro-glycerine and being some modification of blasting gelatine, *e.g.*, ballistite ; the other being mainly composed of nitro-cellulose treated with solvents and gelatinised, or in other ways rendered suitable for incorporation with other ingredients. There are a large number of such powders, and a few examples are here given.

Engel dissolves nitro-cellulose in acetic ether, acetone, etc., adds a nitrate or chlorate and a small amount of hydro-carbon, *e.g.*, naphthalene. The result is a heavy horny substance, with vitreous fracture. (Spec. No. 6,022, 25. 4. 87)

Glaser, a similar patent to above, but starts with his material in the form of sheets or strips. (Spec. No. 17,167, 13. 12. 87).

Nobel proposed 100 parts nitro-glycerine, 10 camphor, 200 benzole, and 50 soluble nitro-cellulose. The benzole is evaporated, and the doughy material mixed by passing through rollers heated by steam to 50 or 60° C. Another mixture is 100 of nitro-glycerine, 10 to 25 of camphor, 200 to 400 acetate of amyl, 200 soluble nitro-cellulose. Nitro-starch may be substituted for a part of the nitro-glycerine. (Spec. No. 1,471, 31. 1. 88).

Anderson dissolves nitro-cotton in acetic ether, diluted with 10 to 20 per cent. benzoline. The proportions are about 32 fluid ounces of the liquid to 1lb. of dry nitro-cotton. The product is "squirted" and allowed to harden. (Spec. No. 13,308, 20. 7. 89).

Maxim treats guncotton with solvents such as acetone or acetone alcohol and ether in an exhausted vessel, so as to get rid of air-bubbles, and obtains a very hard material. (Spec. No. 16,213, 8. 12. 88).

He also adds oil (preferably castor oil) to compounds of dissolved guncotton, nitro-glycerine, etc., to produce a slow-burning explosive for small arms. Suitable proportions are 2 to 5 per cent. castor oil, 10 to 16 per cent. nitro-glycerine and the remainder guncotton. (Spec. No. 4,477, 14. 4. 89).

Gaens mixes di-nitro-cellulose gelatinised by acetic ether with nitre and bumate of ammonia. The bumate is prepared from peat washed and boiled in solution of carbonate of soda. (German patent, D.R., 48,933, 19. 3. 89).

Other smokeless powders have been proposed (or are named) by Aspden, Shires, Studer, Greener, Vielle, "Hornite," Johnson, Borland, Wass, Wetteren, Duttenhofer, Hebler, Turpin, Varley, Brenk, and others.

Grakrult (Skoglund) is a smokeless powder with which experiments have been made by the Swedish navy.

p. 83.—Line 13, for "Shöneweg," read "Schöneweg."

p. 83.—The "Smokeless Powder," licensed under that name, and manufactured near Ware, is defined as follows:—". . . . . Consisting of nitro-lignin carefully purified and mixed or impregnated with a nitrate or nitrates (other than nitrate of lead), and with or without starch or collodion or turmeric or similar vegetable colouring matter, provided that such collodion shall consist of carefully purified nitro-lignin dissolved in commercially pure ether and alcohol, and with or without such other substances as may from time to time be approved by a Secretary of State."

p. 84.—Tonite No. 3 consists of a mixture of di-nitro-benzole guncotton, nitrates of soda, barium, or potash, and chalk. It is a licensed explosive.

p. 85.—When picric acid is burnt the fumes are very bitter, and give a peculiar bitter sensation at the back of the throat. This is a good rough test for even small quantities.

p. 86.—A 1lb. weight falling 26 inches on to picric acid on a steel anvil has exploded it. At 240° F. the height was 14 inches.

p. 86.—The dimensions of the Cornbrook craters were :—

East crater.	West crater.
30′ 4″ × 25′ 8″, and 8′ 3″ deep.	20′ 5″ × 22′ 8″, and 5′ 10″ deep.
(About 1,680 cubic feet).	(About 710 cubic feet).
Estimated amount (?) 7cwt.	Estimated amount 130lbs.

The larger crater was estimated by Captain Friend, R.E., Secretary, R.E. Committee, as about equivalent to that produced by 500lbs. guncotton.

p. 88.—Two varieties of Bronolith have been approved for licensing, and are defined as follows :—

Bronolith No. 1, consisting of a mixture of saltpetre, dextrine, sugar, and charcoal, with or without the addition of picrates of barium, sodium, and potassium, or any of them, and with or without the addition of nitro-napthalene. The amount of picrates in the finished explosive is not to exceed 5 per cent. or the nitro-naphthalene 8 per cent.

Bronolith No. 2 is composed of the same ingredients as No. 1, but there is no limitation as to the amount of picrates. The total amount of saltpetre and nitro-naphthalene is not to exceed 10 per cent.

p. 88.—Eclipse Powder, proposed as a "smokeless powder," consists of picric acid, litharge, sulphur, and charcoal. It was an accidental mixture of picric acid and litharge that was reported to have caused the Cornbrook explosion. See p. 86.

Howittite is a mixture of picric acid with chlorate of potash and nitrate of soda. It is very sensitive, and is unstable. The action of the picric acid on the chlorate at 100° F. is very powerful.

p. 89.—LITHOTRITE, as submitted in 1888, contained only sawdust charcoal, sulphur, saltpetre, and a little nitrate of soda. It is a fine grey powder.

p. 89.—MELINITE. Mr. Guttman informs me that this was originally picric acid embedded in collodion. Later, only fused picric acid was used with a guncotton primer. Nitro-cresol was sometimes added, but subsequently abandoned.

p. 89.—The "Emmens" acid is stated to be—

$$H_2C \, . \, C_{12}H_6\,(NO_2)_6\,O_2 \, . \, H_2O,$$

or intermediate between tri-nitro-phenol and tri-nitro-cresol. (M. No. XVIII., p. 756).

Emmens also makes a "gunpaper" treated with a solution of picric acid and ammoniacal water. (U.S.A. Spec. 423,230, 11. 3. 90). (H.M.).

p. 89.—NOBEL adds 3 parts of nitrate to 1 of picrate of ammonia, and hardens with ½ per cent. of gum or dextrine. (Spec. No. 10,722, 24. 7 88). See Picric Powder, p. 90.

He also mixes charcoal and barium nitrate with picrate of ammonia or amorphous phosphorus. (Spec. No. 1,469, 31. 1. 89).

p. 90.—LIARDET dissolves picric acid in half its weight of boiling glycerine, and adds a proportion of ground cedar or other wood, and nitrate of potash. (Spec. No. 12,427, 6. 8. 89).

p. 92.—The proportions of Hellhoffite for blasting are given as—

Di-nitro-benzene 1 part to 1½ parts of nitric acid.
or Nitro-benzene 1 ,, ,, 2½ ,, ,, ,,

p. 96.—CHAPMAN proposes to dispense with fulminates, and to obtain a longer flash and greater igniting power in cap composition. When used with high explosives there is supposed to be less risk of setting up detonation. One of the compositions is—

Amorphous phosphorus ...	15·90	Peroxide of manganese...	5·20
Potassium carbonate ...	2·00	Magnesium	6·10
Powdered resin	2·00	Potassium chlorate ...	10·90
,, cane sugar ..	2·00	,, nitrate... ...	51·90
,, mercuric oxide	4·00		

(Spec. No. 16,997, 22. 11. 88).

p. 96.—COLLIERY SAFETY LIGHTERS. Roth, and also Zschokke, have proposed the same idea.

p. 97.—DETONATORS. Nobel proposes to substitute for fulminate of mercury various explosive mixtures in a finely granulated condition, *e.g.*, 2 parts collodion cotton dissolved in 12 parts acetone, 1 part nitro-glycerine, 4 parts picrate of potash, and 8 parts chlorate of potash. On evaporating the acetone the product is easily broken into grains, 3,000 to 15,000 to the gramme. (Spec. No. 16,919, 12. 10. 88).

p. 98.—SAFETY FUZE.—Nobel proposes to make the core of a thread composed of camphorated blasting gelatine (15 to 20 per cent. camphor), added to a mixture of 70 parts chlorate of potash, 25 of ferricyanide of potash, and 44 of nitro-cotton. When incorporated, a soft indiarubber-like substance is produced, which is easily worked into thread. The advantages claimed are absolute continuity, imperviousness to moisture, and smokelessness. (Spec. No. 1,470, 31. 1. 88).

NOTE.—The items initialled O.G. are due to information received from Mr. Oscar Guttmann, and those initialled H.M. to Mr. Henry Mosenthal.

BRIGHAM YOUNG UNIVERSITY
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DATE DUE

SEP 1 1981
JUL 9 1982
JAN 2 1982
MAY 1 1982
JAN 21 REC'D
MAR 27 1982
MAR 29 REC'D
SEP 1 1983
AUG 2 REC'D
SEP 07 1984
JAN 18 1985
JAN 18 1985
JAN 31 1985
MAY 30 1985
JAN 20 1987
OCT 21 2002
JAN 04 2004
DEC 19 2003

DEMCO 38-297